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UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 973

Washington, D. C. ▼ June 5, 1923

MILK-PLANT OPERATION

By

CLARENCE E. CLEMENT, Market Milk Specialist, Dairy Division,
Bureau of Animal Industry

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THE NEED FOR TECHNICAL KNOWLEDGE.

The successful operation of a milk plant requires, besides general ability, considerable technical knowledge and training. New milk plants are constantly being established, especially by organizations of producers or of producers and small dealers, and the question of management is of considerable importance. The success of new milk plants usually depends to a large degree on the manager; and capable managers are often difficult to find. Sometimes men can be obtained who have the proper personality and general business ability but lack the technical knowledge for successfully managing a milk plant. The purpose of this bulletin is to give such men, as well as men who are already in the business, information regarding methods used in operating milk plants successfully.

The construction, arrangement, and equipment of milk plants have been considered in previous publications issued by the Department of Agriculture.[1] Certain information regarding operation was also included in these publications. This bulletin describes briefly the various operations in somewhat the same order as they occur in the ordinary city milk plant.

[1] U. S. Department of Agriculture Bulletin No. 849, "City Milk Plants, Construction and Arrangement," and U. S. Department of Agriculture Bulletin No. 890, "Milk-Plant Equipment."

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RECEIVING MILK AT THE PLANT.

The milk as received from producers, directly or through country cooling plants, is usually brought to the plant in trucks, either from the railroad station or directly from the country. These trucks are unloaded at the receiving platform; the milk is graded and dumped, and the cans are washed and returned to the trucks, so that they can go back to the producer to be filled again with milk.

All milk should be received at the plant in the morning, if possible. It is usually desirable to have it all in before noon, so as to avoid hauling during the heat of the day, and so that the work of receiving at the plant may be completed in good season each day.

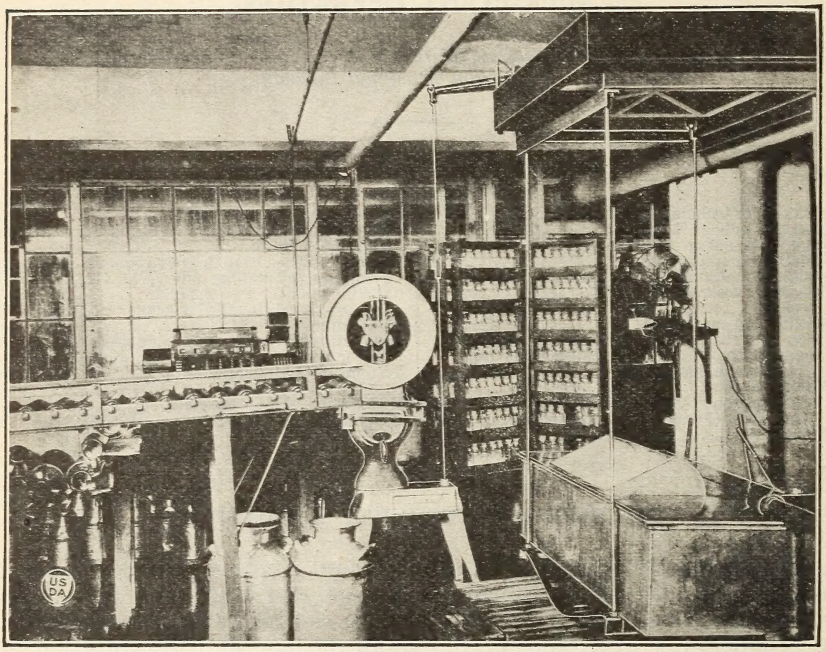

FIG. 1.—Portion of receiving room, showing scales of overhead-lever type, weigh can, conveyer on which cans are conveyed to wash room, and fan to blow flies away from the milk.

The milk-plant manager is responsible for the quality of the milk put out at the plant, and he must therefore direct that the milk is properly cared for at the farm where it is produced. One of the most important points in this connection is that of keeping the milk cool. Producers should be instructed to use ice early in the spring to cool the milk. Usually more sour milk is received at the plant in the spring and fall than during the summer, because producers fail to realize the importance of cooling at these times, and do not begin to use ice early enough nor continue its use late enough.

The manager can help to have the milk arrive at the plant in good condition by having it brought to the plant immediately on arrival at the railroad station, and when it reaches the plant it should be sent immediately to the pasteurizer or kept in a cool place until it is pasteurized. No milk should be allowed to remain in a warm receiving room.

In large cities there is a wide variation in the age of the milk received at the plants. Figures obtained from the principal dealers in five cities on the age of the milk when received showed variations of from 2 to 48 hours, a large proportion being from 12 to 24 hours old.

The milk-plant manager should arrange to have the milk reach the plant as fresh as possible. He is, of course, dependent on train schedules. At some small plants near the source of production it may be advisable to receive the milk twice a day, as it can be kept cold at the plant more easily than at the farm.

GRADING, SAMPLING, AND TESTING.

Milk should be dumped and weighed as soon as received. Each can of milk must be examined to determine its condition. (Fig. 2.)

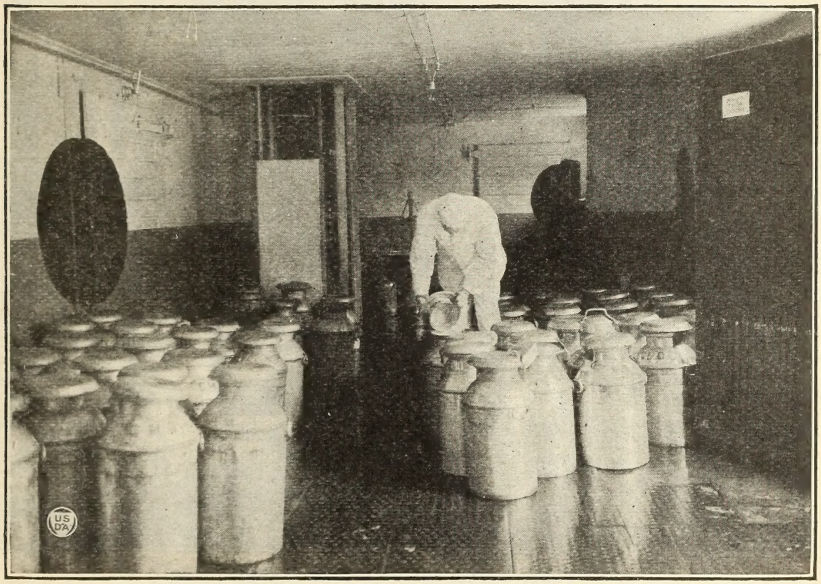

FIG. 2.—Inspection of milk on arrival at plant.

This may be done by smelling or tasting, and milk with objectionable flavors or odors should, of course, be rejected. Fingers or hands should never be put into milk. Spoons used for tasting should be rinsed thoroughly and sterilized after each use.

As soon as the milk is dumped into the weigh can a sample should be taken for the butterfat test. It is to the interest of both dealer and producer to have the sample properly taken and the testing properly done. (Fig. 3.) This question is of special importance, as more milk is now bought on butterfat basis than formerly. A difference between the test at the country receiving station and at the city plant indicates inaccuracy at one place or the other.

At small plants where the milk is dumped from the cans directly into the pasteurizing vat, it may be weighed in the cans. Where this is done a sample should be taken from each can, and care must be taken to mix the milk in the can thoroughly before taking the sample. Much more satisfactory results are obtained by the use of the weigh

can, because then all the milk from each producer can be mixed thoroughly and a fair sample taken. A two-compartment weigh can facilitates the weighing and sampling.[2]

From the time the milk is received and dumped it should be handled rapidly and should be exposed to contamination as little as possible. After the milk is weighed it usually passes through a clarifier or a filter to remove any dirt present. While large plants generally use a clarifier, very satisfactory results may be obtained with the use of a filter consisting usually of layers of cheesecloth and cotton, and considerable expense in equipment eliminated. There are also several types of mechanical filters now on the market

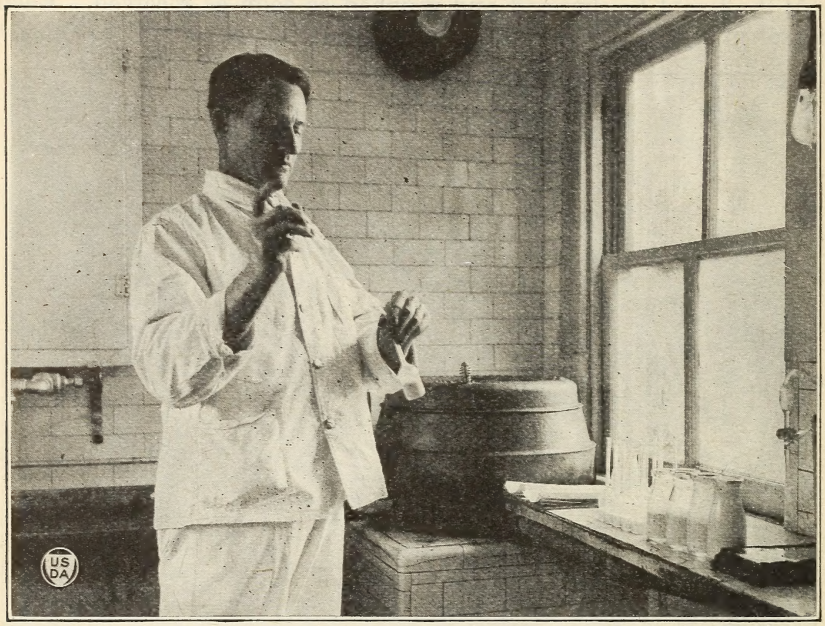

FIG. 3.—Testing milk for butterfat content.

PASTEURIZING AND COOLING.

It is important that the milk be properly pasteurized, and a competent and reliable man should be assigned to this work.

The primary purpose of pasteurization is the destruction of all pathogenic organisms in order to make the milk safe. Where milk is properly pasteurized, disease-producing organisms and nearly all other bacteria are destroyed, so that besides making the milk safe the keeping quality is improved.

In pasteurization two main objects are desired, namely, (1) destruction of all disease-producing bacteria and a reduction of the total bacterial count of the milk; (2) economy in the use of heat, power, and labor. Unless the first is accomplished the second is of little account.

[2] For information on testing milk, plant operators are referred to Bureau of Animal Industry Circular A-12, "Chemical Testing of Milk and Cream," which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 cents; stamps not accepted.

In order to pasteurize milk properly, two things are necessary: 1. The milk must be heated to 145° F. and held for 30 minutes with an accurate control of the temperature and time. After heating and holding, the milk must be immediately cooled to 50° F. or below. 2. All apparatus which comes in contact with the milk must be cleaned thoroughly and sterilized after each using.

Unless there is an automatic temperature control the steam and water valves must be carefully watched in order to maintain the proper temperature. If the milk is not heated to the proper temperature and held at that temperature, good results can not be expected. All pipes or "pockets" in which milk is held during the pasteurizing or holding process should be insulated, as otherwise the holding temperature can not be maintained. Great care must be used also that none of the valves leading from the heater or holder leak. Milk coming from the pasteurizer should never pass through any apparatus which has contained raw milk.

The cleansing and sterilizing of the apparatus is absolutely essential for good results. All milk pipes, pumps, and filler valves, as well as the pasteurizer, should be taken apart after each run, thoroughly cleaned and rinsed, and then sterilized by steam. An abundance of steam should be used. Unless all bottles and cans are thoroughly cleansed and sterilized the value of the pasteurization will be greatly reduced.

The proper pasteurization of milk is a simple operation and there is little excuse for the poor results that are obtained at some plants. Poor results are usually not the fault of the type of pasteurizer used, but of the way in which it is operated.

Following are some of the causes of poor pasteurizing results at milk plants:

Pipes and pumps not cleaned and sterilized.
Filler and valves not cleaned and sterilized.
Milk rushed through the apparatus too fast.
Milk not heated high enough nor held long enough.
Temperature recorder not accurate.
Bulb thermometer not accurate.
Raw milk added to pasteurized milk in vat before the pasteurized lot is all drawn out.
Pumps and piping not of sanitary construction.
Leaky or inaccurate valves, which allow some of the milk to get through the apparatus without being held the proper length of time.
Formation of foam in the holder.

Great care should be taken that valves in the pipe line do not leak. Leaky valves are a very common occurrence in many milk plants, and besides the very insanitary character of such a condition much loss of milk results from it. The prevention of milk loss is an important part of the manager's duties, and no pains should be spared to keep all valves and connections in the milk lines tight.

CONTROL OF PASTEURIZING TEMPERATURE.

One of the most important considerations in the proper pasteurization of milk is control of the temperature. In order to do this properly an automatic device is necessary. It is difficult and often impossible to control the temperature by means of hand valves, but there are on the market automatic devices which will control the temperature very accurately.

With vat pasteurizers it is not necessary for the operator to remain constantly at the steam valve, but it is very important that the steam be shut off at the proper time. Usually the steam must be shut off just before the milk in the vat reaches 145° F. The coil may then be shut down, although some operators favor allowing the coil to revolve during the holding process in order to keep the temperature more nearly uniform and prevent the cream from rising. If the coil is run intermittently, there is much less danger of injuring the cream line than when it is run continuously. The outlet valve should not be opened to let the milk out of the vat to the cooler until 30 minutes have elapsed from the time the temperature of the milk reached 145° F., and no milk must have been added to the vat in the meantime. When continuous-flow pasteurizers are used with no temperature control, the operator must be at the steam valve constantly, and even then it is very difficult to prevent considerable fluctuation in temperature.

When an automatic device for controlling the temperature is used, it is important that the device be properly adjusted at all times.

Temperature recorders should always be used. They should be attached so as to show the temperature to which the milk has been heated. When vat pasteurizers are used the time of holding can be determined from these recorders provided the time it takes to empty the vat is known. Usually the apparatus is attached at a point near the bottom of the vat, and the record will show the total period from the time the milk first reaches the pasteurizing temperature until the vat is practically empty. The time required to empty the vat must, therefore, be deducted from the time of holding, as shown on the record chart, in order to determine the length of time all the milk was held at the pasteurizing temperature. When all or a part of the cooling is performed in the vat the record chart will show the actual time of holding at the pasteurizing temperature for the entire vat of milk.

With continuous-flow pasteurizers it is difficult to record accurately the time the milk is held at the pasteurizing temperature, and this can best be determined by means of an accurate timepiece and by means of accuracy tests.

The charts from the recording instruments are a record of how the milk has been pasteurized, and are often valuable to show health officials as well as customers how the process was performed.[3]

CHECKING ACCURACY OF HOLDERS.

The accuracy of all continuous-flow holders should be tested from time to time. Several different tests are used for this purpose. Automatically operated compartment holders should also be checked often to determine their accuracy. It is essential that the valve of the compartment which has been emptied should close tightly before the next lot of heated milk begins to flow in and that none of the valves leak at any time.

[3] For further information on pasteurization see U. S. Department of Agriculture Bulletins No. 342, Present Status of Pasteurization, and No. 890, Milk-Plant Equipment.

COOLING.

The milk should be thoroughly cooled after heating and holding, and in order to assure this it is necessary that the cooler be of sufficient capacity. When the cooler is not large enough, care must be taken to see that the milk does not pass over it too fast, because if it does it will not be properly cooled. The milk should also be cooled with the least possible agitation.

Milk may be cooled in the vats, but in that case care should be taken not to injure the cream line; to prevent such injury the milk should be cooled quickly, with as little agitation as possible. It is more satisfactory to have a separate cooler large enough to permit quick cooling, so as to increase the capacity of the pasteurizing apparatus. Temperature recorders may be attached to the cooler in order to record the temperatures to which the milk has been cooled.

BOTTLING AND CAPPING.

As soon as the milk is pasteurized and cooled it should be put immediately into clean, sterile, cool bottles. The process of bottling and capping can be carried on at the same time as the pasteurizing process when a continuous-flow system of pasteurizing is used. The capacity of the pasteurizing outfit and the bottle filler should therefore be approximately the same, and this should be such that the work of pasteurizing and bottling in medium-sized and small plants may be done in four or five hours. Then the same set of men can be used during the remainder of the day for other work, such as receiving and weighing the milk and washing the bottles and cans. In small plants where one pasteurizing vat is used, two men can dump the milk into the vat as it is received, and as soon as it is pasteurized it may be run over the cooler, and the same two men can do the filling and capping.

The bottling should be done by machine. A machine capper also is desirable.

MAN-HOUR REQUIREMENTS FOR BOTTLING MILK BY VARIOUS METHODS.

A study was made of the labor requirements in filling and capping milk at milk plants in several of the larger cities in the United States. Figures were obtained for the labor used for the actual bottling and filling; they do not include packing of milk in the storage room after bottling. Five methods of bottling were considered:

1. The large, automatic, power fillers and cappers, which fill and cap the bottles in the case, a full case at a time. (See Fig. 4.)
2. The smaller rotary type of automatic fillers and cappers, which work automatically, but in which the bottles are taken out of the cases, and are returned to them after being filled and capped. (See Figs. 5 and 6.)
3. Automatic single-row fillers and cappers in which bottles are removed from cases and passed through the machines in rows. (See Fig. 7.)
4. Machine fillers and cappers, in which the bottles are filled and capped in the case, but the operations are accomplished by means of hand levers and not automatically.

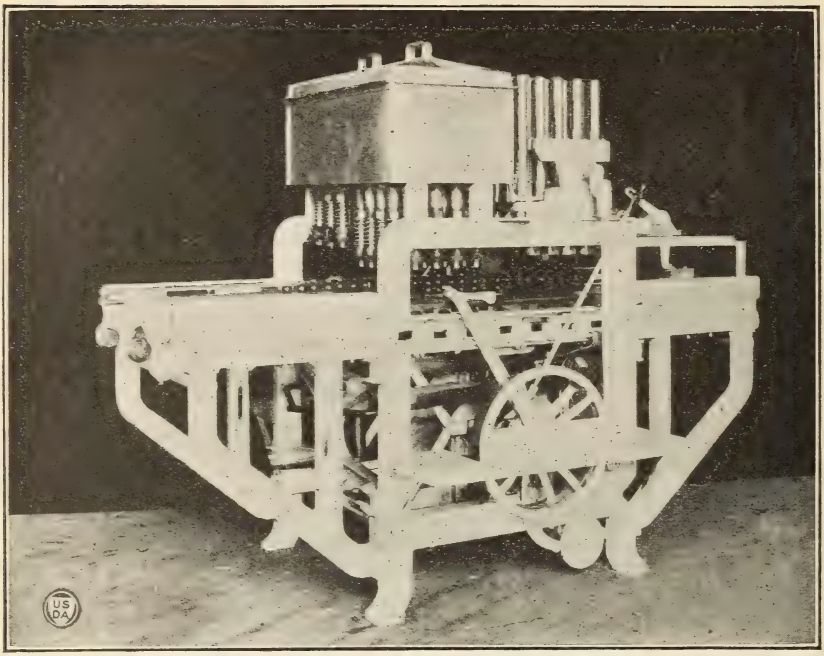

FIG. 4.—Large automatic filler and capper. A case of pints and a case of quarts can be filled simultaneously with this machine. At 15 plants using this type of machine 1,229 bottles were filled and capped per man-hour.

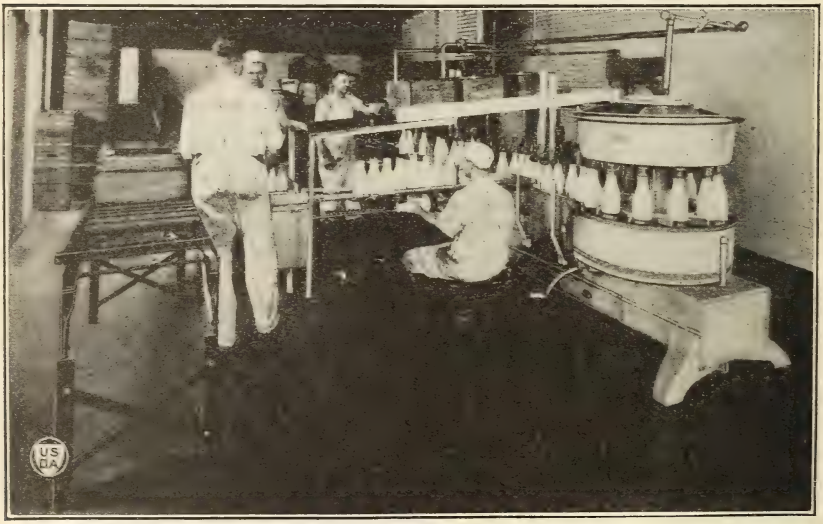

FIG. 5.—Bottling milk with automatic rotary-type machine. At 31 plants using this type of machine the average number of bottles filled and capped per man-hour was 701.

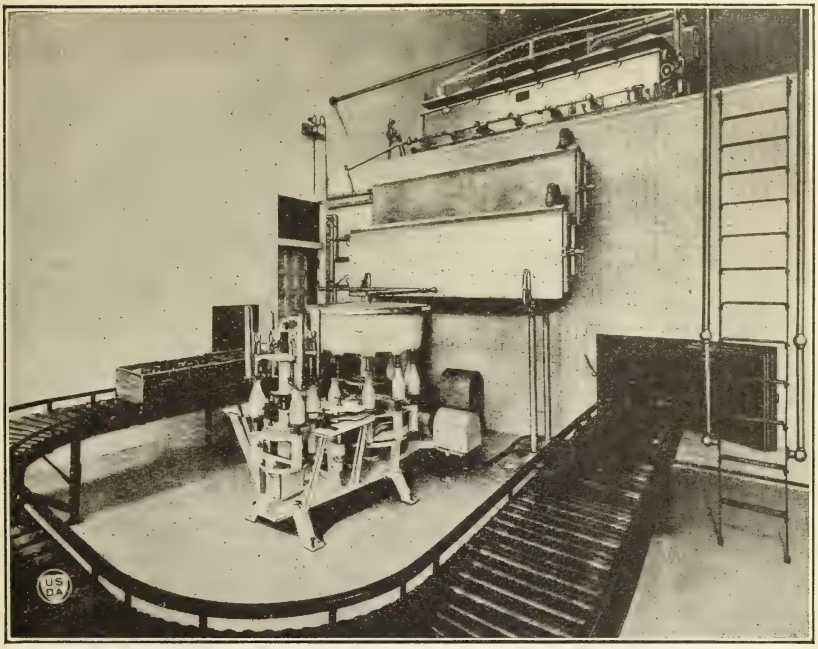

FIG. 6.—Rotary-type filler and capper. Note conveyers used to convey the bottles from the bottle-storage room and, after being filled, to the milk-storage room.

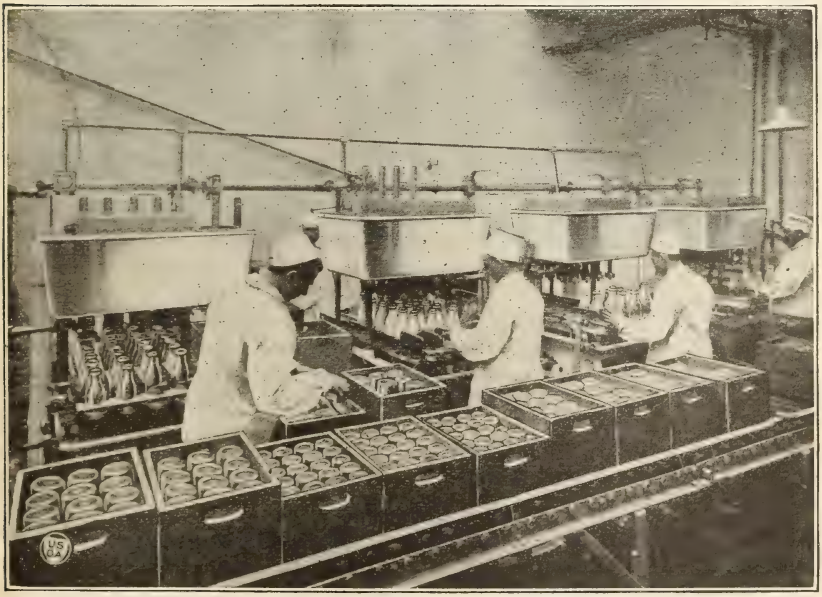

FIG. 7.—A battery of fillers and cappers of the automatic single-row type. An average of 763 bottles was filled and capped per man-hour at four plants using this type of machine.

5. Fillers in which the bottles are filled in a manner similar to the fourth method, but are capped by hand.

Table 1 shows the labor used in filling and capping with the various systems.[4]

TABLE 1.—*Comparative man-hour requirements, on the average, for filling and capping bottles with different types of machines.*[1]

Type of machine.	Plants.	Cities.	Average number of machines used per plant.	Bottles filled and capped per hour.	Bottles filled and capped per man-hour.	Bottles filled and capped per machine-hour.
(1) Large automatic	15	5	1.50	5,994	1,229	3,895
(2) Rotary automatic	31	10	2.00	4,609	701	1,999
(3) Single-row automatic	4	4	3.75	10,136	763	2,080
(4) Machine filler and capper, operated by hand levers	21	8	1.50	3,717	768	2,338
(5) Machine filler, with hand capping	60	5	1.20	1,798	553	1,576

[1] At practically all plants where data on labor used in filling and capping and in washing bottles were obtained, the machines could be so adjusted that half-pint and gill bottles could be handled as well as quarts and pints. The data given were obtained on quart and pint bottles of milk only.

The most important items in this table are those showing the number of bottles filled and capped per man-hour. The largest number of bottles per man-hour (1,229) was filled and capped with the large automatic machine. The number filled and capped per man-hour was not greatly different with the rotary, single-row, and hand-lever types of machine, being 701, 763, and 768, respectively. The number of bottles filled and capped per machine-hour was nearly the same with the rotary and single-row types, being 1,999 and 2,080 respectively, while with the machine filler and capper of the hand-lever type 2,338 bottles were filled per machine-hour. Some of the plants using the latter type of machine had large-capacity machines, but on account of the extra men required to operate these machines there was practically no saving in labor over the other types.

In Table 2 are shown the wide variations in the man-hour and machine-hour requirements at the various plants using the various methods.

TABLE 2.—*Range of variation in the number of bottles filled and capped per hour, man-hour, and machine-hour by the different methods.*

Type of machine.	Bottles filled and capped per hour.	Bottles filled and capped per man-hour.	Bottles filled and capped per machine-hour.
(1) Large automatic	1,933 to 10,958	966 to 2,155	1,933 to 5,479
(2) Rotary automatic	1,350 to 13,333	334 to 1,437	1,114 to 3,966
(3) Single-row automatic	1,833 to 15,077	674 to 838	1,833 to 2,154
(4) Machine filler and capper, operated by hand levers	750 to 7,760	320 to 1,552	750 to 3,880
(5) Machine filler, hand capping	350 to 5,000	238 to 866	350 to 3,200

It can be seen in this table that there is a wide variation in the amount of work done at different plants using the same types of machinery. It will be noticed that there was a wide variation in the number of bottles filled per machine-hour, as well as in the number

[4] For a description of various fillers and cappers, see U. S. Department of Agriculture Bulletin No. 890, Milk-Plant Equipment.

filled per man-hour. The variations in the number of bottles filled per man-hour plainly indicate differences in efficiency of operation at the various plants using similar equipment. There are several factors causing these variations, among which are:

The layout of the rooms and the arrangement of the equipment. This is the most important factor. Many plants were not conveniently arranged for handling the work; hence, extra time and men were required.

In some plants more men were used on the work than could be used economically, while in others too few men were employed to do the work to best advantage.

In the case of some types of machine a difference in capacity, without doubt, accounted for some of the variations, especially that under method No. 4.

Other factors were: Breakdown of machinery, broken bottles, cooler out of order, and waiting for milk. In this connection it is important that the capacity of the clarifier, pasteurizer, and cooler be similar to that of the bottle-filling apparatus, so that both can be operated at a uniform rate and at full capacity.

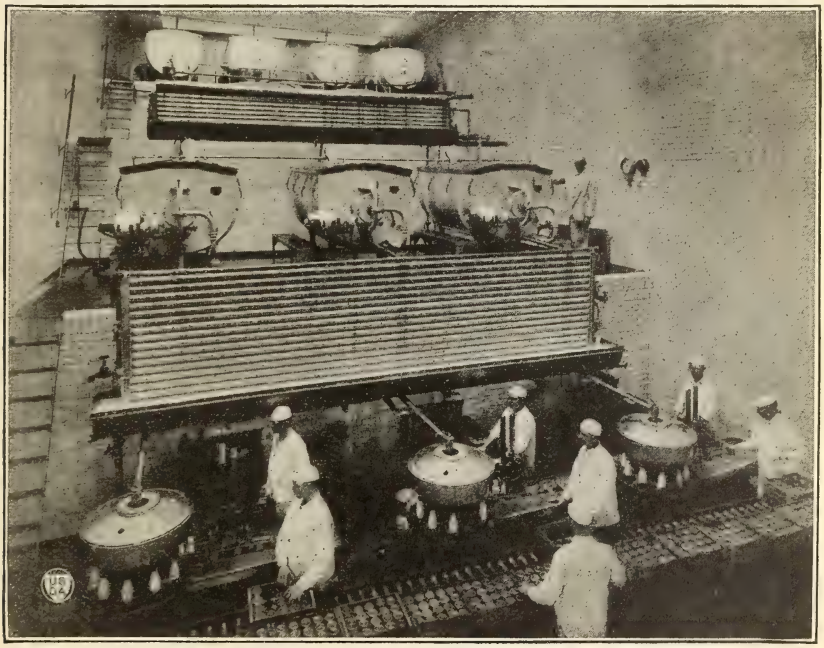

FIG. 8.—Interior view of modern milk plant, showing pasteurizers, coolers, and bottling machinery.

Among the causes of variation in the number of bottles filled per machine-hour are: Layout and arrangement of the machinery as to economy and rapidity of operation, difference in capacity of the machines in some cases, and difference in the efficiency of the labor itself.

All figures given as to number of bottles filled per hour, man-hour, and machine-hour are taken from actual conditions. They do not represent ideal conditions and do not show what the different machines can do when operated at maximum capacity under ideal conditions.

COMPARISON OF LABOR COSTS IN FILLING AND CAPPING BY VARIOUS METHODS.

In Table 3 is shown the number of bottles filled and capped per man-hour at 81 plants using the various methods and filling less than 10,000 bottles daily. Only one machine was used at each plant.

TABLE 3.—*Man-hour requirements at 81 plants bottling milk with one machine and filling less than 10,000 bottles daily.*

Type of machine.	Plants.	Average number of bottles filled and capped per man-hour.
(1) Large automatic	3	1,039
(2) Rotary automatic	13	788
(3) Single-row automatic	1	733
(4) Machine filler and capper, operated by hand levers	9	511
(5) Machine filler, hand capping	55	461

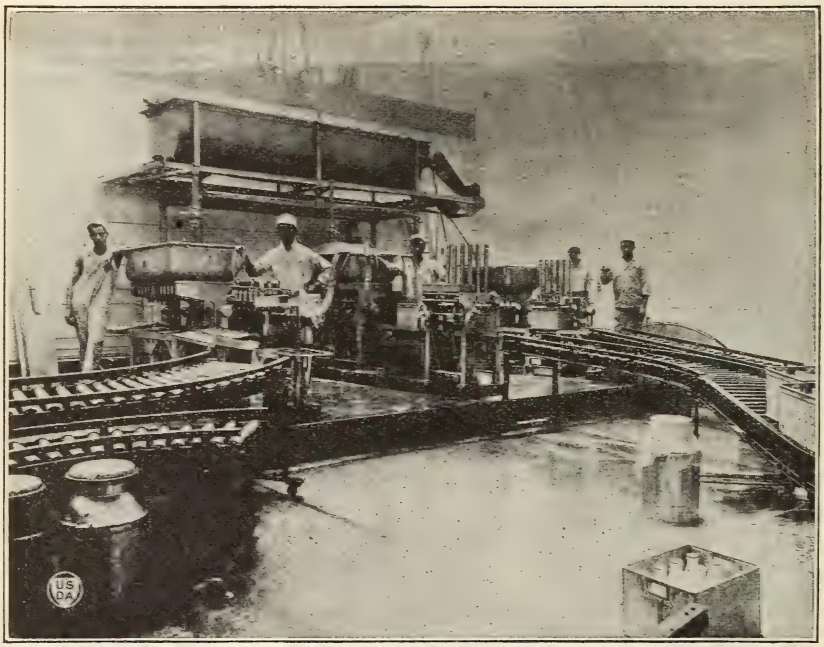

FIG. 9.—A battery of machine fillers and cappers of the hand-lever type. An average of 768 bottles was filled and capped per man-hour at 21 plants using this type of machine.

In Table 4 is shown the number of bottles filled and capped per man-hour at 45 plants filling more than 10,000 bottles daily. The average number of machines used per plant is also shown.

TABLE 4.—*Man-hour requirements for filling and capping at 45 plants filling more than 10,000 bottles daily, with average number of machines in use per plant.*

Type of machine.	Plants.	Bottles filled and capped per man hour.	Average number of machines used per plant.
(1) Large automatic	12	1,238	1.6
(2) Rotary automatic	18	691	2.7
(3) Single-row automatic	3	764	4.7
(4) Machine filler and capper, operated by hand levers	12	838	1.8

Using the data in Tables 3 and 4, it is possible to make a comparison of the labor economy of the various methods of filling and capping for plants of various sizes. The graphs, Figures 10 and 11, are based on these data. Labor in the plant was considered as costing 50 cents an hour and the allowance for depreciation and repairs on the equipment each year was considered as 20 per cent of the purchase price. The values used in the calculations for the various machines were based upon the average prices at which the particular machines used at these plants could be purchased at the time (1922).

Figure 10 shows the comparative costs for labor and for interest and depreciation on equipment for plants bottling less than 10,000 bottles daily and using only one machine. The figures used are taken from Table 3 and are based on labor costs obtained at 81 such plants. It will be noted that for this size of plant, if only one machine is used the automatic machines of the rotary and single-row types are the most economical. The higher purchase price of the large automatic machine makes its use practically prohibitive for plants of small capacities.

The costs with the machine filler and capper

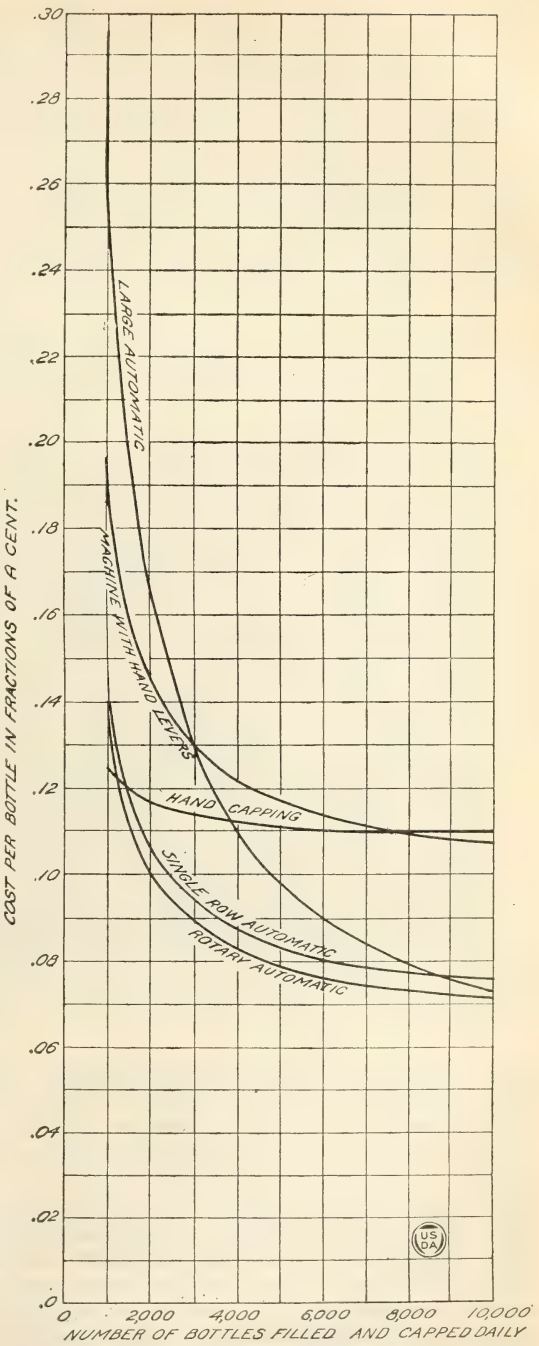

FIG. 10.—Comparative costs for labor and for interest and depreciation on equipment in five methods of bottling milk, where one machine is used, based on labor costs at 81 plants using one machine each and bottling less than 10,000 bottles daily.

operated by hand levers are consistently higher than with the rotary and single-row types of machines for all plants of this group. The costs with the large automatic machine are less than with the hand-lever machine after about 3,000 bottles are reached.

Owing to the high cost of labor, the hand-capping method is not economical for plants bottling more than 1,000 bottles daily. From a sanitary standpoint also this method is undesirable. According to the data obtained there was very little choice as regards cost of operation between the rotary and single-row types of machine. The average purchase price of the machines of these two types is practically the same, and the labor cost at the particular plants studied was only slightly greater with the single-row type. On account of the great variation in efficiency of labor and of plant management, and because these figures are based on only a relatively small number of plants, it would not be possible to say that one of these two types is more economical than the other.

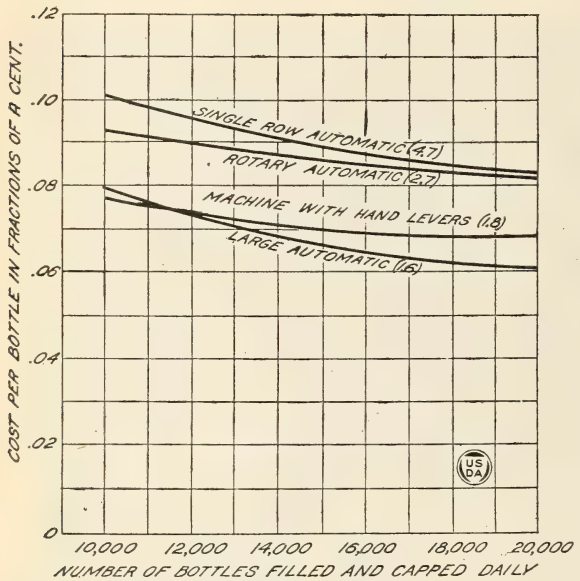

FIG. 11.—Comparative costs for labor and for interest and depreciation on equipment for four months of bottling milk for various-sized plants, computed from labor costs and the average number of machines of various types used at 45 plants bottling 10,000 bottles or more daily. Figures in parenthesis indicate average number of machines in use at each plant. The relatively higher costs with the single-row and rotary machines are due in part to the fact that in many plants some of the machines were not in constant use.

If it should be assumed that at these plants two machines of the rotary and single-row types were used instead of one, and that the bottles filled per man-hour were the same as above, these types would still be more economical than the machine with the hand levers for all plants in this group, while the costs with the large automatic machines would fall below those with the other two types when about 4,500 bottles are reached.

Figure 11 is based on the data in Table 4 obtained from 45 plants bottling more than 10,000 bottles daily. At these plants the average number of machines was 1.6, 2.7, 4.7, and 1.8, for the methods 1 to 4, respectively, and an allowance for interest and depreciation of 20 per cent a year is made on these numbers of machines for each method. The same values for the machines were assumed as before. Owing to the comparatively large number of machines that were used at the plants using single-row and rotary machines the costs with these machines are higher than with the other two methods, because of the larger amount that must be charged for interest and depreciation. It will be noted that at these plants the costs with the rotary and

single-row machines are approximately the same. As more machines of the single-row type than of the rotary type were used at these plants, making a greater charge for interest and depreciation, the costs with the former are slightly greater. In the case of the machine with hand levers and the automatic case-filling machine, the cost per bottle with the latter becomes comparatively less as the size of the plant increases.

At first glance the curves in Figure 11 seem to indicate that the costs of using the single-row and rotary machines were considerably higher than at plants using the large automatic and hand-lever types. In part, however, this is due to the fact that many of the plants using the former types had some machines which were not in constant use. In some cases an extra machine had been installed to take care of emergencies, such as breakdowns. This is a wise precaution against having the work come to a standstill, but the high cost of the large automatic types operates to prevent having extra large machines.

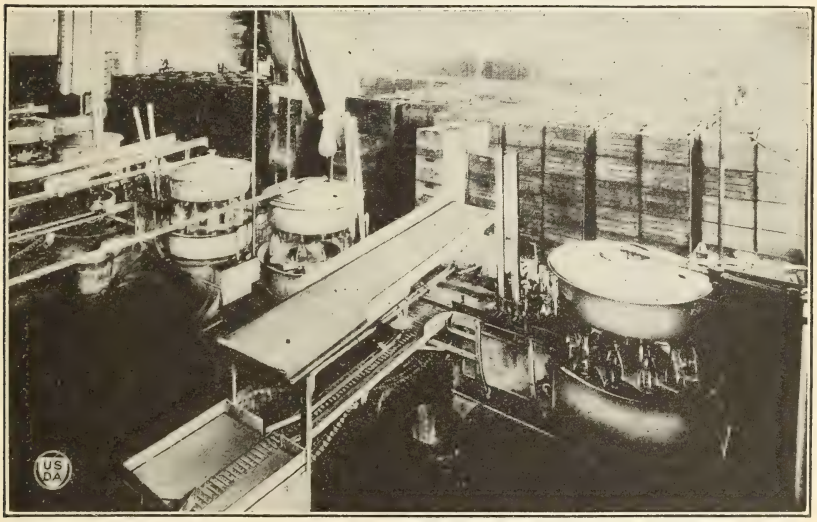

FIG. 12.—A battery of rotary automatic fillers and cappers, with special conveyer system which reduced the number of men required to operate the machines.

The difference in actual cost at these plants between the rotary and single-row machines on the one hand and the hand-lever and large automatic machines on the other, is not great, and other factors are involved which have resulted in the more general use of the rotary and single-row types. Among the advantages of the latter types are:

The smaller machines are more convenient because they are more adapted to be used in units. If one machine breaks down the work will not have to stop, as the other machines can be operated while the broken one is being repaired. As the business increases, additional units can be readily added.

Inspection of bottles can be much more readily carried on with these types of machines, as the bottles are removed from the cases in the operation.

The machines are automatic and the results are not wholly dependent on the men.

As compared with the automatic machines that are used for filling bottles while in the cases ("case-filling machines"), there is less mechanism to get out of order and the operation is much more simple with the smaller types of machine.

WASHING BOTTLES.

The milk bottles should be washed in ample time to be thoroughly cool before they are filled with milk. If the bottles are not cool, the temperature of the milk put into them is raised. This means a waste of refrigeration, and an increased development of bacteria is possible. At many plants bottles are washed in the morning and filled in the afternoon. Great care should be taken to see that the bottle washer is always in working order, for if the bottles are not properly cleaned and sterilized the pasteurization of the milk may be of little value.

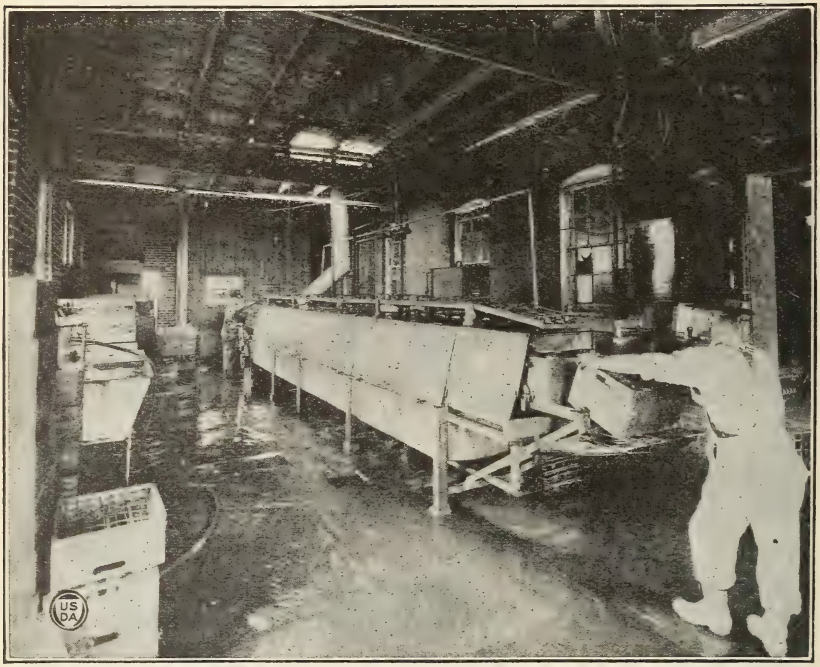

FIG. 13.—Automatic bottle washer. An average of 1,002 bottles per man-hour was washed at 56 plants using machines of this type.

In case a brush washer[5] is used, the brushes should be changed before they become worn, and the washing water should be changed often during the day. Great care must be taken to see that the rinsing and steaming device of the machine is in good working order at all times. Each bottle should receive a strong jet of rinsing water and then a jet of steam for at least 45 seconds. Jet openings should be free from obstructions. After the bottles are washed they should be kept in a cool, clean place until wanted for filling. If the bottles are inverted in the cases, there is less chance for contamination. It is a good plan to use special cases at the washer and transfer the bottles, after they are washed and steamed, to clean, dry cases. If the same cases that are used in the washer are used also to store the bottles, there will be a constant drip from each case into the case below, and these cases also soon become soggy. If

[5] For a description of types of bottle washers see U. S. Department of Agriculture Bulletin No. 890, "Milk-Plant Equipment."

this course is followed, the empty bottles should be inverted in the cases so as to avoid the drip from the next case above.

At medium-sized or large plants automatic pressure washers are commonly used. (See Fig. 13.) These machines also give the cases a washing and steaming which keeps them in good condition. Where these automatic washers are used care must be taken to see that all the jet openings are working at all times and that the solutions in the various tanks are kept at the proper strengths and temperatures. The temperature in the first tank should not be above 100° or 120° F. at the highest, so that the bottles will not be broken. Each succeeding tank should be a little hotter until the final tank, which should be near the boiling point.

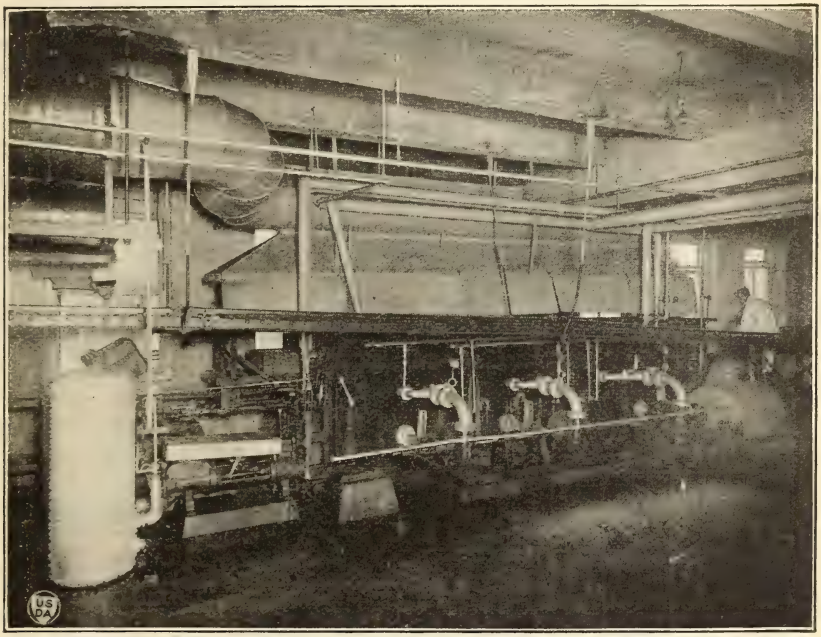

FIG. 14.—Automatic bottle washer showing pumps; thermometers indicate the temperatures in the various tanks.

In small machines of this type with only two or three tanks, the increase in temperature of the water in the various tanks is more sudden. Table 5 gives temperatures observed in the various tanks at several plants. (See Fig. 14.)

TABLE 5.—*Temperatures observed in the various tanks of automatic-pressure washers at several plants.*

Plant No.	Number of tanks.	Temperatures of the various solutions in tanks.				
		Tank 1.	Tank 2.	Tank 3.	Tank 4.	Tank 5.
		°F.	°F.	°F.	°F.	°F.
1	5	120	140	160	180	200
2	4	90	120	160	200	.....
3	4	100	120	140	170	.....
4	3	110	150	180	.....	.....
5	3	90	140	180	.....	.....

MAN-HOUR REQUIREMENTS FOR WASHING BOTTLES.

A study of the labor required for washing bottles was made in different cities at plants using various types of machines. In Table 6 are given the man-hours of labor used in washing bottles at various plants, arranged according to the number of bottles washed daily. Two types of bottle washers are considered:

1. The automatic-pressure washer, which consists of a series of tanks containing washing solutions and rinsing waters, which are forced into the bottles through jets by powerful pumps.

2 The ordinary brush washer, which consists of a mechanically driven brush, with tanks in which the bottles are soaked and rinsed, and a chamber for steaming the bottles.

In the column showing "number of bottles washed per man-hour" it will be noted that for the plants using automatic washers the number of bottles washed per man-hour tends to increase, and the number of man-hours required to wash 1,000 bottles tends to decrease with the size of the plant. The group of plants washing from 20,000 to 40,000 bottles daily is an exception to the general tendency, because one plant in this group used an exceptionally large amount of labor, thus making the average labor cost for the whole group considerably greater than it would be if this plant were eliminated. This particular plant had an arrangement that was very expensive (as to number of men required) for transferring bottles from the wash rooms to the clean-bottle storage room and thence to the filling room. The bottles, too, were transferred to another set of cases before going to the washer, thus requiring considerable extra labor. Sixteen men were used at this plant in the bottle-washing department, while the average for the group is only 4.6 men.

TABLE 6.—*Hours of labor employed for washing bottles at plants of various sizes, using various methods.*

Number of bottles washed daily.	Plants.	Average number of bottles washed per plant.	Average number of men per plant.	Average number of man-hours per plant.	Number of bottles washed per hour.		Number of bottles washed per man-hour.		Number of man-hours used per 1,000 bottles washed.	
					Average.	Variation.	Average.	Variation.	Average.	Variation.
Automatic washers (1 machine):										
10,000 or less	19	6,079	2.7	6.0	2,497	1,296 to 5,400	1,004	648 to 1,691	1.00	0.59 to 1.54
10,001 to 20,000	12	16,146	3.6	15.6	3,622	2,523 to 5,000	1,036	780 to 2,169	.96	.46 to 1.28
20,001 to 40,000	17	28,811	4.6	31.2	4,278	2,760 to 7,916	920	281 [1] to 2,209	1.10	.45 to [1] 3.55
40,001 to 60,000	5	51,587	6.2	48.4	6,614	4,666 to 10,187	1,035	694 to 1,718	.94	.58 to 1.44
Over 60,000	3	79,333	8.0	72.0	8,815	7,556 to 11,111	1,102	855 to 2,519	.91	.40 to 1.17
Average for 56 plants		23,125	4.0	23.1	4,628	1,296 to [2] 11,111	1,002	281 to [2] 2,519	1.05	.40 to 3.55
Automatic washers (2 machines):										
50,000 to 90,000	4	63,500	13.2	110.0	7,582	5,555 to 10,588	577	375 to 844	1.73	1.19 to 2.66
Turbine brush washers:										
1,000 or less	10	626	1.6	2.1	447	250 to 780	305	250 to 400	3.28	2.5 to 4.0
1,001 to 2,000	17	1,503	2.4	4.2	710	233 to 1,700	360	233 to 566	2.77	1.8 to 4.3
2,001 to 3,000	9	2,321	2.4	7.3	685	430 to 1,150	317	215 to 525	3.16	1.9 to 4.6
3,001 to 5,000	7	3,943	3.1	11.0	952	400 to 2,400	358	250 to 525	2.79	1.9 to 3.7
Above 5,000	6	8,700	5.0	29.3	1,582	1,000 to 3,200	297	200 to 800	3.37	1.2 to 5.0
Average for 49 plants		2,704	2.6	8.4	928	[2] 233 to 3,200	323	[2] 200 to 800	3.0	1.2 to 5.0 [2]

[1] One plant in this group used an exceptionally large number of men for this work.
[2] Total range of variation.

In the case of the plants using the brush washer there is no definite relation between man-hours used and the size of the plant. It will be seen in the columns "Number of bottles washed per man-hour" and "Number of man-hours used per 1,000 bottles washed" that there is no regular increase or decrease in those figures with the size of the plants. At small plants using the brush washers the men are usually shifted from one kind of work to another and the work of bottle washing is not so well systematized as is the case at larger plants. At the plants using the automatic machinery the larger plants are able to economize on labor. On account of the large volume of work of a similar nature that has to be done, such plants naturally use special efforts to eliminate all labor not essential, and use special men for each type of work.

One of the outstanding points illustrated by the data in Table 6 is the large variation in the quantities of labor required at the various plants of similar size using the same type of equipment. For example, at 12 plants washing from 10,000 to 20,000 bottles daily with automatic washers, the number of bottles washed per man-hour varies from 780 to 2,169. Apparently the less efficient plants in this group could reduce their labor costs by adopting the methods used at the more efficient plants. The most obvious cause of such variations seems to be the arrangement of the various plants. Many plants are very inconveniently arranged, so that extra men are required to transfer the bottles from place to place, and in many instances some of these men could be eliminated by a rearrangement of the rooms and equipment in the plant.

It will be noted in the table that at plants washing more than 5,000 bottles daily with brush washers the work is done even less economically than at the smaller plants. The average number of bottles washed per man-hour at the larger plants is only 297, while the average for all plants using brush washers is 323. From a study of the figures in Table 6 it seems evident that such plants could operate more economically if they would install automatic bottle washers. In the group of plants washing 10,000 bottles or less daily with automatic machines, an average of only 1 man-hour is required per 1,000 bottles washed; while in the group of plants using brush washers, an average of 3 man-hours is required to wash 1,000 bottles.

Table 7 shows the average numbers of bottles washed per hour and per man-hour at 111 plants, using the methods (1) automatic machine, (2) brush washer, and (3) swabbing out with a hand brush. The variations in the man-hour requirements with the various methods are also shown.

TABLE 7.—*Hours of labor (average) used in washing bottles, also variations in number of bottles washed per hour, man-hour, and machine-hour, at 111 plants using the different methods.*

Method of washing.	Automatic machine.	Brush washer.	Hand washing.
Number of plants	56	49	8
Number of cities	15	10	3
Bottles washed per hour	4,628	928	433
Variation	1,296 to 11,111	233 to 3,200	180 to 950
Variation in number of bottles washed per machine-hour	1,296 to 7,916	233 to 2,400	
Bottles washed per man-hour	1,002	323	199
Variation	281 to 2,519	200 to 800	135 to 266
Man-hours used per 1,000 bottles washed	1	3	5

A wide variation in efficiency is also shown where the same method of washing is used. There are many factors that cause these variations, as, for example, some of the machines of the same type are more serviceable and of a larger capacity than others; also, the operators are delayed from time to time by numerous unavoidable causes, such as breakdowns, broken bottles, or lack of steam, but the greatest factor in causing these variations is the arrangement of the plant. The management and handling of labor are also important factors.

COMPARISON OF COSTS IN WASHING BOTTLES.

Using the data in Table 7 as to number of bottles washed per man-hour, it is possible to make a comparison of costs in washing bottles by the various methods for plants of various sizes. According to this table the average number of bottles washed per man-hour at 56 plants using one automatic washer each was 1,002; at 49 plants using brush washers, 323; and at 8 plants washing with a hand brush, 199. Assuming that labor is worth 50 cents an hour, which is about the average at these plants at the present time (1922), the labor cost per 100 bottles washed would be 4.99 cents, 15.48 cents, and 25.13 cents for the three methods respectively. The capacity of the automatic washer used at the various plants varied considerably, of course, but a fair estimate of the present average purchase price of the automatic machines used at all the plants is $3,500.[6] For the brush washer the average current price (1922) for the particular types used would be about $400. Assuming that the depreciation and other annual expense on the bottle washers is 20 per cent of their purchase price, this charge would amount to $1.92 a day for the automatic machine, and $0.22 a day for the brush washer. In the case of hand washing this extra charge would not be worth considering. Using these averages for labor cost and for interest and depreciation on the machines, Figure 15 was worked out to show the relative costs for labor and interest and depreciation on the equipment of the various methods for plants washing different numbers of bottles daily. The cost per bottle is shown in the left-hand margin, while the number of bottles to be washed is shown in the bottom margin.

Hand washing is represented by a straight line, as the labor cost would be the same per bottle, regardless of the number washed, and no charge for interest and depreciation is considered. The line showing the cost with the brush washer crosses that representing the cost with the automatic machine at about 1,600 bottles, indicating that when this or any larger number of bottles is to be washed it would be advisable to consider the economy of installing an automatic washer. The high wages that have to be paid for labor in the plant have an important bearing on this question. The hand-washing system is out of the question for any plant at present prices (1922) of labor and the brush washer is economical only at very small plants.

A similar graph was worked out to represent conditions in 1914 previous to the present high prices for labor and equipment. This is shown in Figure 16. The labor costs used were the average for 40 plants using automatic washers, 43 plants using brush washers, and 8 plants where the bottles were washed by hand. The average number

[6] Such plants should also have a brush washer to take care of the very dirty bottles. Such a brush would add slightly to the total cost.

of bottles washed per man-hour was 1,044, 342, and 199 for the three methods, respectively. These numbers were not greatly different from those given in Table 7, upon which the costs in Figure 15 were based. The cost of labor at the plants where the data were obtained was approximately 20 cents an hour in 1914. At that time the average purchase price of the machines used in the plants was approxi-

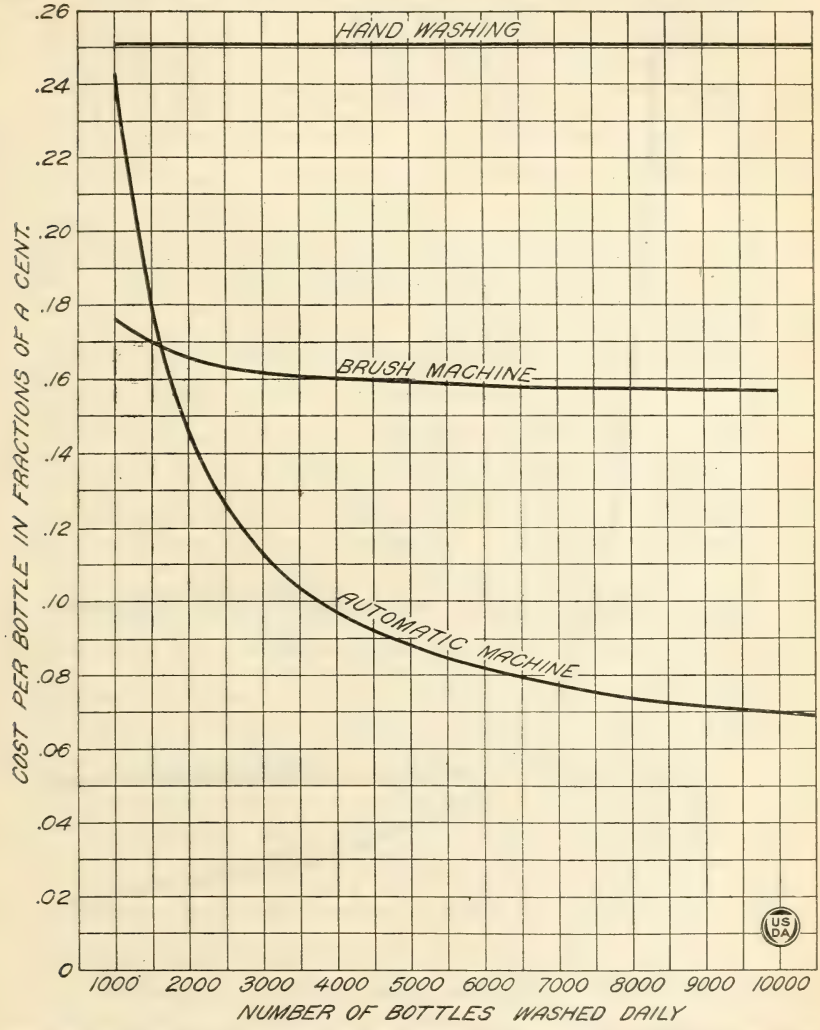

FIG. 15.—Comparative costs for labor and for interest and depreciation on equipment, with three methods of washing bottles, based on labor requirements at 113 plants. (Prices of 1921.)

mately $1,500 for the automatic machines and $175 for the brush washers. The lines representing the automatic and the brush-washing types intersect at about 2,300 bottles, indicating that when this number of bottles was reached it would have paid a dealer to consider the economy of changing from an ordinary brush washer to the automatic machine.

By comparing Figures 15 and 16 it is apparent that even though equipment is much more expensive now (1922) than in 1914, the

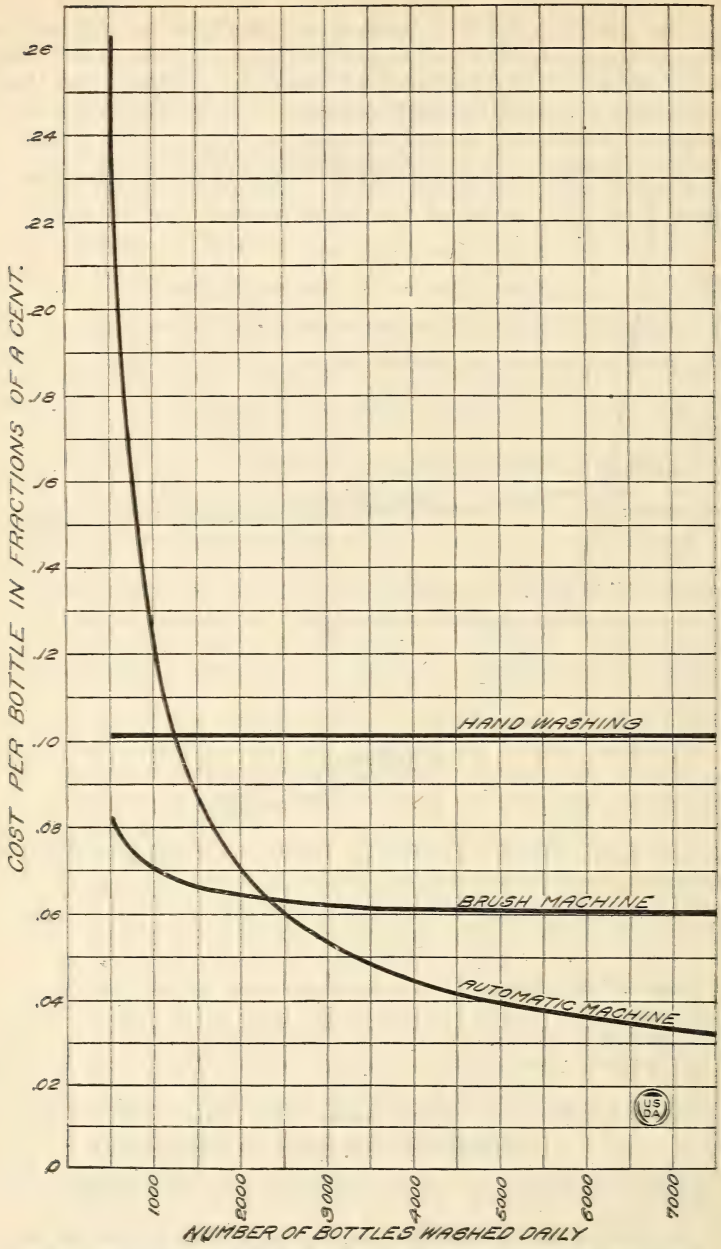

FIG. 16.—Comparative costs for labor and for interest and depreciation on equipment in washing bottles by different methods at plants of various sizes, based on labor costs at 91 plants and prices for 1914. The cost of both labor and machinery has greatly increased since these figures were obtained: the figures are useful, however, to show the comparative costs with the different methods used.

economy of using machinery is even more obvious than at that time, owing to the fact that the cost of labor is so much higher than it was in 1914. According to Figure 16, hand washing was more economical than the automatic machine for plants washing less than 1,200 bottles daily, while the brush washer was more economical than the automatic machine for plants washing up to about 2,300 bottles daily. According to Figure 15 hand washing is not economical for plants even of the smallest size, and the brush washer is economical only for plants washing 1,600 bottles or less.

In the illustrations it can be seen that in order to determine the relative economy of the various methods of washing bottles the cost of the machine and of labor in the particular locality must be carefully considered. The variation in the efficiency of different men must be taken into account also.

Another factor to be considered in determining which type is the most economical is the time required to wash a given number of bottles. Time in the milk plant is an important factor, and methods of operation must be followed that will provide for the work being accomplished in a definite time. It will be noted that at 56 plants using automatic washers the average number of bottles washed per hour was 4,628, while at 49 plants using brush washers the average number of bottles washed was only 928. Thus if a plant has, let us say, 5,000 bottles to wash it will take, according to these figures, more than five hours with a brush washer, while the work could be done with an automatic machine in a little more than an hour. It is generally desirable at medium-sized or small plants that the bottle washing take no more than half of the day, so that the men doing this work can be employed elsewhere during the remainder of the day. For example, one set of men may wash the bottles in the morning and bottle milk in the afternoon. In that case the bottle washing must be done in from three to four hours. It is therefore necessary at such plants to select a bottle washer which will permit the work to be done in this time, and as a general rule it is to the advantage of the dealers handling this number of bottles to use the automatic rather than the brush washer. Where only one or two men are washing bottles and they are not suitable to help in filling bottles, it may be economy to keep them washing bottles for the greater part of the day; in that case a brush washer would be satisfactory, provided they could wash all the bottles with it in from six to eight hours. In any case, however, thoroughness is of first importance, and such methods should be used as will result in the most thorough cleansing and sterilization.

In the discussion of labor costs in bottling milk and in washing bottles, no attempt has been made to include all types of machinery. The studies made include the more common types in use, although other more recent types are on the market.

INSPECTION OF BOTTLES.

While the large automatic pressure washers give satisfactory results in general, there are always some bottles that will not be thoroughly cleaned. Bottles that have stood for several days, or those in which the casein of the milk has dried, will pass through the machines without being properly cleaned. It is necessary that all such bottles be culled out and washed with a hand brush before they are sent through

the automatic washer. It is a good plan to soak these very dirty bottles overnight in a solution of washing powder. To take care of such bottles it is advisable to have a small brush washer (without rinsing apparatus) besides the automatic pressure washer.

Besides culling out dirty bottles before they enter the machine, it is necessary that the bottles be inspected after they leave the machine. (See Fig. 17.) Milk delivered in a dirty bottle often means the loss of a customer, besides being objectionable from a public-health standpoint. In large plants inspectors are often so placed that the bottles are inspected as they leave the bottle washer, again before they are filled, and finally after being filled with milk; and even then it is possible for some dirty bottles to get out to the trade. Some dealers

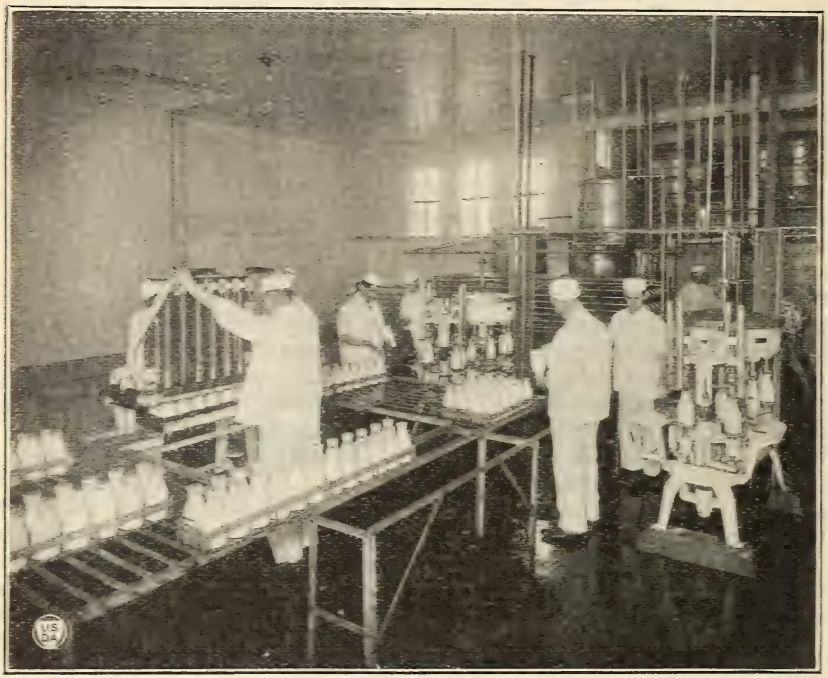

FIG. 17.—Filling and capping bottles by machinery. Note inspection of bottles both before and after filling.

have considered the advisability of washing all bottles on a brush washer before they go to the automatic machine, in order that all dirty ones will be thoroughly cleaned. As a rule this would cause needless extra expense, since even with this method an inspection system would be required. After the bottle is filled with milk the the dirt often shows much more plainly than before filling it, making it important that the bottle be inspected after it is filled.

At one plant a rather unique and satisfactory method of bottle inspection was used. The inspector at the bottle washer was held responsible for all dirty bottles that he let go through to the filling room. He was paid on a commission basis, as was also the inspector at the fillers. For all dirty bottles found by the inspector at the filling machine he was paid a certain premium and the commission of

the inspector at the bottle washer was reduced a similar amount. In this way the men took a special interest to prevent bottles from passing without careful inspection.

As it is very important that the bottles be thoroughly cool before the milk is put into them, and as they must be kept clean while cooling, a separate room for storing clean bottles should be provided in the plant, unless there is a bottle-cooling arrangement between the bottle washer and the fillers.[7]

WASHING CANS.

The matter of washing cans, while only a small part of the daily operations, is a very important one. Many different methods are used at various plants in caring for the cans after the milk is removed from them. There are a number of different types of cleaning machines on the market. The aim of the efficient ones, however, is thorough cleansing with washing powder and water, followed by rinsing, sterilization with steam, and rapid drying. After this the can should be covered and kept from contamination. Some of the largest machines are fitted with powerful pumps, and as the cans in an inverted position are run through the machine, sprays of washing powder and water, rinse water, hot water, and steam successively are forced into them under considerable pressure. They are then dried in the same machine by a blast of hot air.

Very satisfactory results can be obtained at small plants by washing the cans thoroughly with a hand brush and water to which washing powder has been added. The cans should then be rinsed and steamed with a jet of live steam for at least 45 seconds. After steaming, the cans should be allowed to stand for a few seconds until thoroughly dry. Covers should then be placed on them. It is important that the cans be well dried, and if they are subjected to sufficient steaming they will become dry in a few seconds. Not only does drying leave the can in a better condition as to cleanliness, but it tends to prevent rust and prolong the life of the can. The cover should be thoroughly washed and steamed before being returned to the can.

SANITATION IN CITY MILK PLANTS.

The importance of cleanliness in the handling of milk can not be overestimated. In order to put out a high quality of milk, both cleanliness and care in handling are required. On arrival at the plant, the milk should either be put in a cold place or immediately started on its course through the plant. The cans of milk may either be put into the refrigerator or have ice packed around them, or the milk may be stored in tanks provided for the purpose. These tanks should be in a cold room or insulated with a jacket, so that the milk may be kept at a low temperature until it is put through the plant. The milk should be strained or put through a clarifier or a filter which removes the greater portion of insoluble dirt in the milk. At small plants satisfactory results can be obtained from the use of a simple strainer or filter of cheesecloth and cotton. Some sort of rack or holder is necessary to support the filter; the cheesecloth is first laid on one of these holders and then some sterilized cotton is placed on

[7] See U. S. Department of Agriculture Bulletin No. 849, "City Milk Plants—Construction and Arrangement."

it and the cheesecloth folded over it. Another rack is then placed over the whole. The filter is then attached either to the dumping device or to the receiving tank. It will be necessary usually to change the filter during the day (depending on the quantity of milk handled), as the cotton will become filled with dirt; also, if care is not taken, the cotton may get out of place so that some of the milk will pass through without going through the cotton. The cheesecloth must be thoroughly washed and sterilized after each use, and kept in a clean place. It can be used several times before it is thrown away. The cotton should be thrown away after it is used once. The milk should pass through the various pieces of apparatus with as little exposure to the air as possible; and after pasteurization, cooling, and bottling it should be kept in the cold-storage room until taken

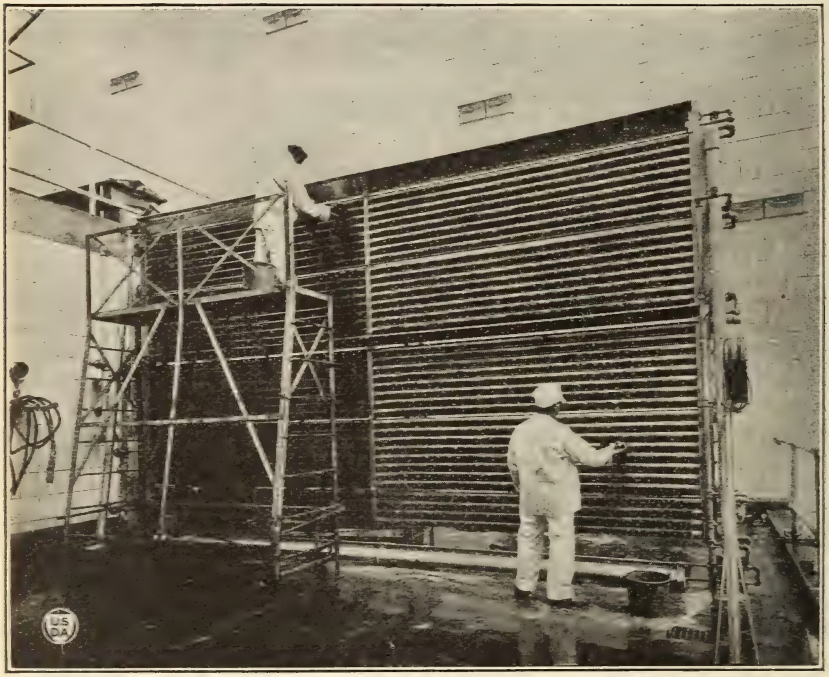

FIG. 18.—Cleaning a milk cooler in a large plant. It is later steamed.

to the delivery wagons. It is very essential that the milk be cooled to 50° F. or below and held there until delivered to the consumer.

As soon as the milk is put up, all parts of the apparatus should be cleaned thoroughly by first rinsing in cool or tepid water, then washing with hot water to which washing powder has been added, and finally sterilizing with boiling water or steam. (See Fig. 18.) After the milk has passed through the apparatus it is a good plan to pump cool water through the entire system first, and then hot water to which washing powder has been added. The pumps and pipes can be rinsed by pumping water through them immediately after using. They should then be taken down and thoroughly washed, which can easily be done if there are frequent hand couplings in the pipes. After washing and rinsing the pumps and pipes they should be steril-

ized with steam. The cleaning and sterilization of the milk piping and pumps are often neglected. While it is sometimes possible to clean the pipes satisfactorily by means of pumping solutions through them, followed by thorough rinsing and steaming, usually this is not sufficient. It is much more satisfactory to take down and clean the piping thoroughly every day. At many plants complaints are received about the quality of the milk, that it turns sour quickly, etc., and the operator is often at a loss to know what the trouble is, as he has been careful with the temperatures used in pasteurization and the milk is kept cold after pasteurization. Often the trouble is found to be with the milk pipes, joints, and pumps. If the pipes are not thoroughly cleaned and sterilized each day, filth and dirt will soon collect at joints and elsewhere, and the milk passing through

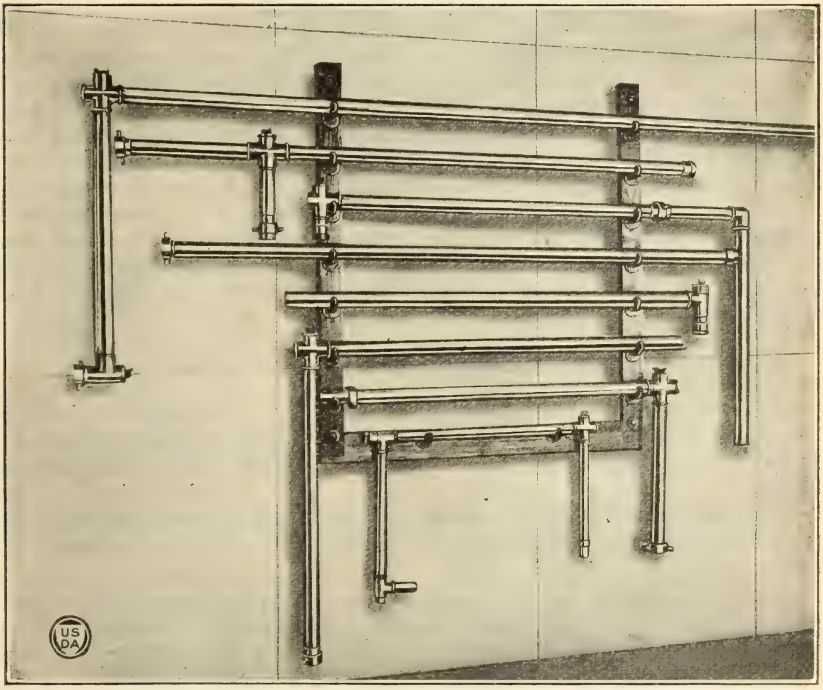

FIG. 19.—Milk piping after being disconnected, washed, and steamed.

such apparatus will be badly contaminated and will be of very poor quality.

Great care should be taken in cleaning the pasteurizing outfit. This should be rinsed immediately after using, and then thoroughly cleaned and finally rinsed and steamed. Small brushes must be used to get at the parts of this apparatus and no effort should be spared in keeping the pasteurizer clean. After the work with the milk has been finished, water should be run through the apparatus, followed by water to which washing powder has been added, and a thorough cleaning with brush, then rinsing and steaming.

Much attention should be paid to keeping flies out during the warm season. All windows and doors should be well screened. Revolving fans placed near and blowing toward the door, which should open

outward, will often greatly assist in reducing the number of flies that enter the building. These fans provide a constant breeze, which forces many of the flies out as the doors are opened. Fans placed near milk apparatus, such as open coolers, also tend to keep flies away from the apparatus and out of the milk. Good ventilation is essential. (See Department Bulletin No. 849, "City Milk Plants.")

Keeping a milk plant clean is a simple matter if one bears in mind the fundamentals of sanitation and has a fair idea of bacteriological principles. Everything with which the milk comes in contact should be kept clean from a bacteriological standpoint—that is, thoroughly sterilized with steam. Milk should be exposed to the air as little as possible; it should be pasteurized at 145° F. for 30 minutes and then kept at 50° F. or below until delivered.

The delivery outfit is another item that should receive attention in respect to cleanliness. Many dealers naturally take great pride in the cleanliness of their plant. The delivery outfits should not be forgotten, for customers have an opportunity to see them every day, while only a few ever visit the plants. The horses should be kept in good condition and well groomed, the harnesses clean and well oiled, and wagons well painted and washed. Drivers should be clean, neatly dressed, courteous, and obliging. Many a good customer has been lost by a discourteous driver, while many a new one has been gained by a polite and obliging one. A uniform or a white suit adds much to his appearance. Where cash sales are made in office buildings or other places in which the customer deals directly with the driver this is especially desirable.

WASTES INCURRED IN HANDLING MILK.

One of the aims of the milk-plant operator is to keep the losses in the plant as low as possible. These losses vary considerably at different plants, depending mostly on the competence of the men in charge.

There are many items which should be borne in mind by the milk-plant operator in keeping down losses. The following items are important:

Avoid milk piping as much as possible by the proper arrangement of rooms and equipment. Not only is the piping difficult to keep clean, but it causes extra labor. Besides, considerable milk will stick to the pipes at the end of the run, and extra piping will increase the loss of milk.

Avoid use of milk pumps wherever possible by use of the gravity-flow system. Extra labor is required for cleaning pumps, and the gravity system is more sanitary.

Keep a close watch for leaks, spillage, slop, etc., in the milk handling, so as to keep the shrinkage as low as possible.

Drain cans well after dumping the milk.

Have milk vats set so that they can be readily drained.

Keep all joints in milk pipes tight to avoid leaks.

Utilize all milk returned by drivers, and drain the containers after dumping.

Shut down motors or other machinery as soon as through using them, and thus avoid power waste.

Avoid extra shafting, pulleys, etc.

Avoid extra steam piping by proper arrangement of rooms, and thus avoid losses due to condensation of steam.

Keep steam valves and joints well packed to avoid leakage.

Keep all machinery well oiled, but avoid waste of oil by careful use and by catching the drip.

Avoid water wastes. Save water from cooler coils and from condenser coils whenever possible. Too much water used in washing also requires extra washing powder. Water hose should not be left running when not needed.

Utilize exhaust steam whenever possible to heat water for use in the plant; also to heat boiler-feed water, and to heat the building.

Avoid waste of ice. Leaving ice on cement floors in workroom or exposed to drafts causes unnecessary waste.

Keep doors of refrigerator room closed. Do not work in refrigerator more than necessary, and do not leave the lights burning.

Eliminate breakage of glass as much as possible. Bottles broken at the fillers cause the loss not only of the bottles, but of considerable milk, often more than a bottleful. Do not throw away the broken glass if it can be sold to glass blowers.

Avoid extra labor by convenient arrangement of rooms and equipment, and by use of labor-saving devices, when practicable.

Avoid as much as possible agitation of the milk in handling.

MILK-BOTTLE LOSSES.

The loss of bottles at milk plants is an important item. Estimates of the large dealers in five cities were averaged, and, according to their figures, the average life of a glass bottle was 22¼ trips. The results are seen in Table 8.

TABLE 8.—*Estimated life of glass milk bottles as given by some of the principal dealers in five cities.*

City.	Number of dealers.	Average trips.	Variation.
Washington	3	12.60	8 to 18
Baltimore	8	18.00	4 to 50
Boston	13	28.50	10 to 50
Philadelphia	10	20.80	6 to 30
Pittsburgh	6	21.60	8 to 40
Average or total	40	22.25	4 to 50

Bottles of various sizes cost (1922) in large lots, on the average, 6 cents each, so that if a plant uses 10,000 bottles and has to replace them every 22.25 days, the expense is $26.96 a day.

Some dealers now charge their family customers for all bottles not returned and the custom of charging store customers for the bottle is quite common. A ticket is usually given the store customer when he pays for the bottle, and the amount paid is returned upon the surrender of the ticket and a bottle. Where a bottle is returned each time a bottle of milk is taken away no ticket or charge is required. A special bottle is often used for the store trade, and in that case no ticket is required.

One of the means used by dealers in many localities to reduce the loss from stolen or misplaced bottles is the establishment of milk-bottle exchanges. These exchanges are in operation in many of the larger cities, where they serve as a sort of clearing house, mislaid bottles being collected and returned to their owners. The establishments of the milk dealers are visited regularly and all bottles belonging to other dealers are brought to the exchange headquarters, where they are washed, sterilized, and sorted. Usually very little or nothing is paid by the exchange for bottles collected in this way, but sometimes dealers bring in their stray bottles, the price they receive varying from one-fourth cent to 1 cent for each bottle. Bottles brought in by junk dealers, ash men, or other persons are also paid for. The city dumps are visited by employees of the exchange and many bottles are obtained from this source. In one city where the exchange kept a record of the number of bottles thus recovered,

1,500,000 were obtained in three years. The usual charge for bottles returned to the owner is from one-half cent to 3 cents each. Cans, jackets, bottle cases, and other articles which constitute a milk dealer's delivery equipment are also handled by some of the exchanges. In many cases the exchanges are operated by dealers, who generally are stockholders.

In some exchanges a small profit is made, though the object of the exchange is not to make money, but simply to help the dealers recover their bottles, and the latter can well afford to pay the small price asked. While these exchanges do away with but a small part of the large loss of bottles incident to the milk business, yet they are a useful

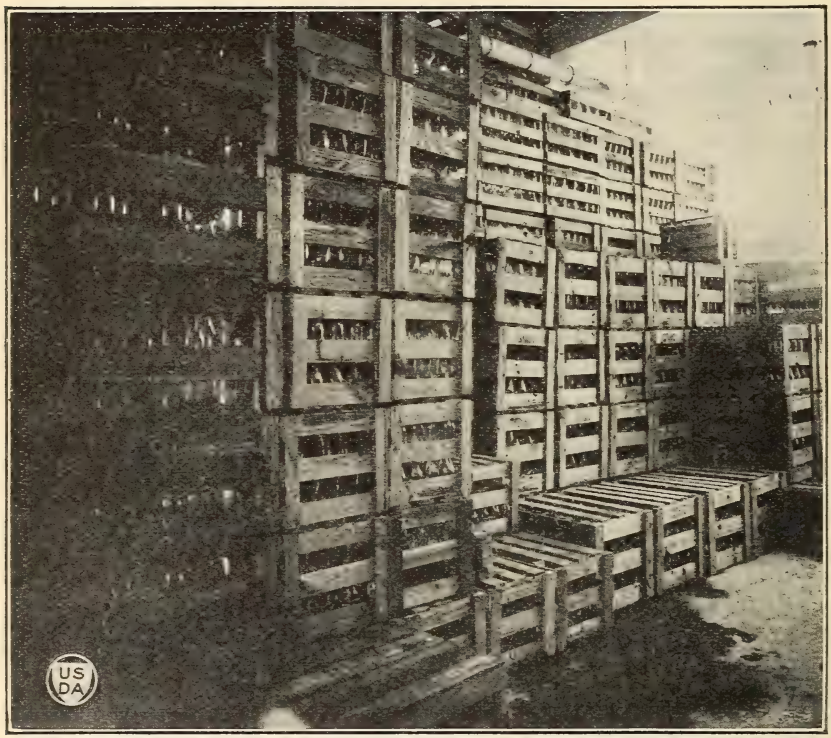

FIG. 20.—Dealers must keep a large supply of bottles on hand. Fifty dealers bought on the average 120 bottles a month for every 100 bottles filled daily.

factor in reducing expenses, and dealers in those cities where such exchanges do not exist would do well to consider this subject with a view to organizing an exchange.

All milk plants should have a system of checking up their drivers on the number of bottles brought back each day. Drivers often become careless even when there is such a system; but if no record is kept, the losses are of course much greater.

People are often ignorant of the value of the bottles and sometimes break them, throw them into the ash barrel, or use them for other purposes. Many dealers send special notices to the consumers in regard to the necessity of returning bottles; this tends to eliminate some of the carelessness.

Many bottles are broken in the plant, though some dealers are helping to eliminate this loss by instructing their men as to the value of the bottles and the need for careful handling. Some keep records of the number broken. Most dealers sell the broken glass to the glass blowers for a certain price per ton, but many small dealers still pursue the wasteful practice of throwing it into the dump. Unless the bottles are too cold when washed, fewer are broken with the large automatic washing machines now in use than is the case with the hand-brush method of washing, for the reason that there is less handling. It is very important that the bottle cases be in good condition and hold the bottles firmly, especially where they are moved on gravity conveyers.

Table 9 is a summary of the replies to a questionnaire on bottle losses of 50 dealers grouped according to number of bottles filled daily.

In some cities the business carried on by junk dealers is one of the worst sources of loss in milk bottles; not only do they sell the bottles to dealers in the city but often ship them to other towns. It is often difficult to get convictions against junk dealers in cities where the stores are charged for bottles, for the reason that bottles used for family trade and belonging to the dealers can not be distinguished from the store bottles which have been paid for. However, if a special bottle were used for the store trade by all the milk dealers this trouble would be lessened.

TABLE 9.—*Summary of 50 replies to questionnaire on milk-bottle losses.*

Size of plant (bottles filled daily).	Number of dealers.	Average bottles filled daily.	Average bottles bought per month.	Average bottles bought monthly per 100 filled daily.	Average cost of bottles per month.[1]	Average cost per month per 100 filled daily.[1]	Average number bottles lost and broken daily per 100 filled.	Proportion of broken to lost bottles.[2]	Trips per bottle.[2]
Up to 1,000	5	740	523	70.6	$27.60	$3.73	4.6	1 : 0.8	21
1,001 to 2,000	7	1,685	1,114	66.1	51.47	3.05	2.6	1 : 1.7	13
2,001 to 5,000	5	3,800	5,756	151.5	238.00	6.26	5.0	1 : 2.5	14
5,001 to 10,000	16	7,906	9,446	119.5	326.50	4.13	3.8	1 : 5.3	15
10,001 to 50,000	13	23,332	20,135	86.3	1,079.40	4.63	4.2	1 : 8.8	17
Over 50,000	4	67,500	90,050	133.4	3,071.00	4.55	4.3	1 : 13.0	19

[1] Based on 1917 prices. [2] Dealers' estimates. Estimates were not received from all the dealers.

The problem of keeping down the loss of bottles deserves the attention and study of all dealers. Whatever radical change is made in the system used at present to reduce the loss, cooperation by all the dealers in a particular city seems to be necessary.

The following suggestions have been offered by various dealers and health officers for the solving of the milk-bottle loss problem:

A charge made for every bottle, all dealers to enforce this rule.
The use of single-service fiber bottles only.
Commission to drivers for bottles returned.
Education of consumers as to the great loss.
Efficient milk-bottle exchange.
No bottle, no milk.
Special bottles for the wholesale and store trade, and charge made for the bottle.
Compel the use of bottles with name blown in the bottle. Must be used by the owner only.

Universal interchangeable bottle.
Federal control, as State and city are too lenient.
Forbid the use of bottles recovered from the dumps.
Federal publicity campaign.
Laws prohibiting junk dealers from handling milk bottles.
Laws compelling consumers to return the milk bottles.
Penalty for use of milk bottles for anything but milk.
Use of special bottle cases in the plant to prevent breakage.

GOODS RETURNED FROM DELIVERY ROUTES.

Another source of loss and added expense in the milk business is the large quantity of goods returned from delivery routes and the uneconomical disposition made of the returned goods. Some dealers make special efforts to keep the returns as low as possible, while others do not, probably figuring that it is cheaper to have large returns sometimes rather than to take the risk of having the driver run short and being obliged to send out extra goods by special delivery. It is to the dealer's advantage to keep the returns as low as possible, while at the same time taking proper care of the trade.

The figures in Table 10 were obtained from a dealer operating 25 routes, and show the quantities of the various goods returned, expressed in per cent of those taken out.

TABLE 10.—*Quantities of various goods returned at a representative plant with 25 routes, in per cent of goods taken out.*

	Goods returned.		
	Total year.	Month of October.	One Monday in October.
	Per cent.	*Per cent.*	*Per cent.*
Gallons milk (bulk)	5.0	2.0	4.5
Quarts milk	4.3	4.0	4.5
Pints milk	5.2	6.0	7.5
Half-pints milk	3.1	4.0	7.0
Quarts certified milk	6.4	6.0	6.2
Quarts buttermilk	20.0	22.0	26.0
Gallons cream	6.6	10.0	12.0
Quarts cream	4.0	3.0	6.3
Pints cream	16.0	16.0	20.0
Half-pints cream	8.8	9.0	11.0
Half-pints whipping cream	25.0	23.0	23.2

Among the most common methods of disposing of returned goods are the following:

Sell the same day as cash sales at the plant or for special orders.
Sell to peddlers the same day.
Sell on the wholesale routes the next day.
Sell on the retail routes the next day.
Separate and sell the cream to the trade the next day.
Separate and sell cream to ice-cream dealers or butter stores, or dispose of it at the butter, ice cream, and cheese departments of own plant.
Sell sour cream to certain classes of trade for family use.
Sell sour milk to cottage-cheese dealers.
Use in the manufacture of casein, milk sugar, albumen, etc.
Use in the manufacture of buttermilk.

Each dealer has to study his own conditions, since what may be the best way for one dealer may not be suitable for another. Most

dealers seem to favor the method of dumping all returns and disposing of the cream for butter and ice-cream purposes. A second grade of buttermilk obtained by making butter from this cream can also be disposed of to bakeries. In this way returns are handled at small expense, and the danger of old milk going out to the trade from this source is eliminated. Using returned milk a second time on delivery wagons is a practice to be discouraged.

Among the methods used to keep the returned goods as low as possible are the following:

Use the quantity of goods returned by the route salesman as one of the points on which his commission is based. This, however, should be counterbalanced by a commission on sales so that there will be an incentive for the driver to take out enough to supply his customers.

Give prizes of diffierent amounts each month to drivers who return the least during the month.

Require drivers to pay 1 cent per bottle for all goods returned above 6 per cent of that taken out.

SHRINKAGE IN HANDLING MILK.

The shrinkage of milk in handling is an important item and every effort should be made to keep it as low as possible. The following table gives the shrinkage for a series of days at three plants.

TABLE 11.—*Shrinkage of milk at city plants.*

	Daily receipts at plant.	Quantity bottled.	Daily loss.	
	Gallons.	*Gallons.*	*Gallons.*	*Per cent.*
Plant No. 1	1,221	1,184	37	3.0
	1,000	976	24	2.4
	1,200	1,162	38	3.2
	1,100	1,071	29	2.6
Average	1,130	1,098	32	2.8
Plant No. 2	1,324	1,299	25	1.9
	1,295	1,274	21	1.6
	1,492	1,468	24	1.6
	1,395	1,385	10	.7
Average	1,376	1,356	20	1.4
Plant No. 3	1,049	1,004	45	4.3
	1,021	979	42	4.1
	1,087	1,046	41	3.8
Average	1,052	1,009	43	4.1

At one small plant where the milk was received by weight and pasteurized in a vat the loss in pasteurizing and bottling was as follows:

	Quarts.
Milk received, 1,254 pounds	583
Received from filler	572
Shrinkage	11

or 1.9 per cent.

As the milk was received by weight, this loss was nearly all due to carelessness. By taking special care for one day, the plant operator was able to reduce the shrinkage to 0.53 per cent. This was the actual loss in pasteurizing and bottling when the milk was handled carefully.

Losses from shrinkage as reported by 115 dealers varied from 0.3 per cent to 7 per cent, and the average was 2.29 per cent. Such losses are largely due to the following causes:

Leaky cans.
Dented cans.
Cans not full.
Careless handling of cans in transferring from cars and dumping.
Inefficient draining of cans.
Leaky or battered apparatus.
Fillers out of repair, and leaky valves.
Losses at the filler. These may be caused by improperly adjusted valves, carelessness in handling, breakage of bottles, etc.
Carelessness in handling full cases of milk, thus breaking the bottles.
Loss from milk left in the pasteurizer, pipes, pumps, tanks, or other apparatus.
Loss from process of pasteurizing, separating, homogenizing, and clarifying, by evaporation and mechanical losses.
Loss by transferring milk and cream from bottles to cans, as in the case of returns from the routes.
Shrinkage in cooling milk.
Breakage of bottles in transferring on conveyers usually due to poorly constructed cases.

There is necessarily a certain amount of shrinkage in transferring milk from cans to bottles and in the process of clarifying and pasteurizing. Special attention to this matter, however, should reduce these losses considerably. Collecting pans should be placed under all milk apparatus where milk is apt to spill and especially under the filling machines.

CHECKING MILK THROUGH THE PLANT.

Every milk plant, whether large or small, should have as a part of an adequate accounting system a method of keeping a check on all milk received and handled through the plant. On the following pages are given some of the forms that may be used in checking the milk handled at small plants. No attempt is made to describe the general accounting system.

CHECKING GOODS HANDLED IN PLANT.

There are many milk losses connected with a milk plant that are sometimes overlooked. For example, a driver may go out with more milk than is charged to him, or he may receive credit for returning more milk than he actually returns, or a quantity of milk may be sent out "special delivery" and fail to be charged. To check up such mistakes and losses a balance of all goods handled at the plant should be made out each day. Figure 21 is a stock balance sheet that is adaptable for a small dealer operating from 5 to 10 wagons.

The method of using this stock balance sheet is as follows: The "stock on hand" may be taken at any definite time, depending upon conditions in the plant, as at 6 p. m.; but it should be at the same time each day. (The "stock on hand" at the bottom of the sheet will be carried forward to the following day as the "stock on hand" at the top of the new sheet.) To this item is added all goods received at the plant during the day. The total of these items is the total to be accounted for. On the credit side of the balance are put all sales, known losses, etc.; this total added to the quantity on hand should equal the total to be accounted for. If all records are care-

fully kept each day this balance should show only a small quantity over or short. In case an extra large quantity is found short on any day, the plant superintendent knows that something is wrong somewhere; either some item was not charged or a leak has occurred, and it is for him to find where it is.

Form L. ....., 192

DAILY BALANCE OF STOCK.

	Milk.				Cream.					But-ter-milk.	Skim milk.	But-ter.	Eggs—Dozen.	Tickets.
	Lbs.	Gals.	Qts.	Pts.	Lbs.	Qts.	Pts.	Half pts.	¼ pts.	Gals.	Gals.	Lbs.		
On hand 6 p. m. previous day														
Received from producers														
Total to be accounted for														
Disposition made of milk														
Sales Route No. 1														
Sales Route No. 2														
Sales Route No. 3														
Sales Route No. 4, etc														
Plant sales														
Special deliveries														
Manufactured														
Separated														
Spilled														
Broken														
Total														
On hand 6 p. m														
Over														
Short														

Fig. 21.—Form for checking goods handled through plant.

If a system like this is followed, many unnecessary losses may be eliminated, and the plant superintendent will know each day just how he stands. A monthly balance sheet similar to this one may be used also as a check on the losses for the month.

CHECKING THE DRIVER.

Each driver should be charged with the goods he takes out on his route and should be credited for all goods returned. The forms A and B (Fig. 22) may be used to check the routes out and in.

When the driver comes in from his route he makes out his order for the following day on Form A. (Fig. 22.) This quantity is put up the same day by the plant, and the driver is given exactly this amount when he loads the following morning. If changes are made before the driver leaves, these may be noted under "Extras."

FORM A.—DRIVER'S ORDER.

Route..... Wanted..... 192 .

	Milk.			Cream.					Buttermilk.	Skim milk.	Butter.
	Gals.	Qts.	Pts.	Gals.	Qts.	Pts.	½ Pts.	¼ Pts.	Qts.	Gals.	Lbs.
Order.....	15	205	105				15		20		5
Extras.....	5	5									
Total.....	20	210	105	.....	.....	.....	15	.....	20	.....	5

FORM B.—DRIVER'S RETURN RECORD.

Route..... Returned..... 192 .

	Milk.			Cream.					Buttermilk (Gals.).	Skim milk (Gals.).	Butter (Lbs.)	Bottles returned.			
	Gals.	Qts.	Pts.	Gals.	Qts.	Pts.	½ Pts.	¼ Pts.				Qts.	Pts.	½ Pts.	¼ Pts.
Returned.....	10	10	5				5				5	150	150	20	
Returned 2nd trip.....															
Total.....	10	10	5				5				5	150	150	20	

FIG. 22.—Forms for checking driver out and in.

On his return from the route the driver enters the quantity of goods returned on the return record, Form B. (Fig. 22.) The difference between the totals on Forms A and B is the amount of net sales for the day or the amount the driver must account for.

CHECKING THE SHIPPING AND RECEIVING CLERKS.

At some plants it is important that the man who delivers the goods to the drivers and the one who receives the returns from them should account for all goods handled or received. Form H (Fig. 23) is an example of a form that may be used to check the shipping clerk; and Form K (Fig. 24), one that may be used to check the receiving clerk.

Form H.

Date.....

BALANCE OF SHIPPING CLERK.

	Milk.			Cream.					Butter-milk.	Skim milk.		Butter.	Cheese.
	Gals.	Qts.	Pts.	Gals.	Qts.	Pts.	½ pts.	¼ pts.	Qts.	Gals.	Qts.	Pounds.	Pkgs.
On hand, 6 p. m.													
Delivered to Route 1													
2													
3													
4													
5, etc.													
Cash sales													
Broken or spilled													
Total													
On hand 7 a. m.													
Total													
Over													
Short													

FIG. 23.—Form for checking shipments taken out by drivers.

Form K.

BALANCE OF RECEIVING CLERK.

	Milk.			Cream.					Butter-milk.	Skim milk.		Butter.	Cheese.
	Gals.	Qts.	Pts.	Gals.	Qts.	Pts.	½ pts.	¼ pts.	Qts.	Gals.	Qts.	Pounds.	Pkgs.
On hand 6 a. m.													
Received from Route 1													
2													
3													
4													
5, etc.													
Total to account for													
Turned in to butter department													
Turned into by-products													
Other deliveries													
On hand 6 p. m.													
Total													
Over													
Short													

FIG. 24.—Form for checking the man who receives the returns from drivers.

NUMBER OF MEN REQUIRED TO OPERATE MILK PLANTS.

The average number of workmen employed in a milk plant, also of route foremen, office clerks, etc., is shown in Table 12 for 153 plants of various sizes. Wide variations occur in plants of similar sizes, but a general idea may be obtained from this table for purposes of comparison.

TABLE 12.—*Number of men employed in 153 milk plants of various sizes.*

Gallons milk handled daily.	Number of plants.	Plant employees (not including office force).		Delivery routes.			Administrative force.		Office force.		
		Average gallons handled daily per plant.	Average men per plant.	Average number routes per plant.	Average number routes per 100 gallons handled daily.	Average number routes per route foreman.	Average per plant.	Average per 100 gallons handled daily.	Average per plant.	Average per 100 gallons milk handled daily.	Average number of routes per office employee.
Up to 100	4	85	1.0	1.0	1.2	.....	.....	.....	.....	.....	.....
101 to 250	18	168	1.7	2.4	1.4	.....	0.52	0.31	0.52	0.31	4.7
251 to 500	31	390	2.8	4.4	1.1	.....	.74	.19	.77	.20	5.7
501 to 1,000	35	788	5.7	9.8	1.2	6.7	1.1	.14	2.7	.34	3.7
1,001 to 1,500	15	1,303	7.2	12.4	.9	6.0	1.0	.08	2.4	.18	5.2
1,501 to 2,000	11	1,745	11.5	20.5	1.2	7.0	1.4	.08	4.7	.27	4.3
2,001 to 3,000	12	2,621	14.6	25.4	.97	8.0	1.3	.05	5.6	.21	4.5
3,001 to 5,000	16	3,921	20.5	37.9	.96	7.1	1.9	.05	7.7	.20	4.9
5,001 to 10,000	7	7,357	32.7	62.6	.84	7.4	2.1	.03	14.1	.19	4.4
Over 10,000	4	17,250	85.8	138.2	.80	9.7	3.0	.02	44.2	.25	3.1

From the average number of routes per 100 gallons the approximate average load carried by the dealers with plants of various sizes can be determined. It will be noted that the larger dealers have fewer routes per 100 gallons handled than the smaller ones. This is owing in part to the fact that in many cases they handled a greater proportion of bulk milk.

The average number of routes per route foreman varied, but as a general rule the larger dealers were able to economize in this respect and more routes were handled per route foreman than in the case of the smaller dealers. The number of administrative officers, also, was proportionally larger at the smaller plants. The number of office employees required in proportion to the number of routes depends more on the system of accounting used than on the size of the business. Some of the large dealers have many more office employees per route operated than some of the smaller ones.

Table 13 presents some interesting information as to the number of men employed in plants in different cities. Figures from the principal plants in each city were obtained.

TABLE 13.—*Men employed in plants in different cities.*[1]

Location of plant.	Average number routes per route foreman.	Average number routes per office clerk.	Average number routes per stableman.[2]	Average number gallons handled per milk handler.[3]	Average number routes per milk handler.[3]
Buffalo	7.0	6.5	7.0	125	1.8
Milwaukee	12.2	6.3	6.3	212	2.1
Minneapolis and St. Paul	9.5	7.9	.....	204	2.0
Cleveland and Akron	[4] 4.5	4.5	7.5	167	1.5
Baltimore	7.5	6.4	5.0	186	2.3
Philadelphia	7.0	7.0	9.7	216	1.7
Washington	.....	3.0	7.3	171	1.7
Boston	6.3	4.3	4.6	288	1.5
Pittsburgh	6.1	3.9	5.1	317	2.1
Detroit	10.2	6.4	10.1	271	2.0
Seattle	9.3	4.7	8.6	200	1.8
Spokane and Butte	10.0	2.5	10.0	123	1.4
Portland, Oreg	[4] 4.1	6.8	.....	140	2.1
Los Angeles and San Francisco	7.6	5.9	.....	277	2.0

[1] According to data collected in 1916–17.
[2] As a general rule, horses and wagons are used for retail milk delivery, and these figures indicate the number of men required to take care of the horses.
[3] Under this heading are included all men in the plant whose work deals with the milk department, including engineers and firemen.
[4] Includes collectors and solicitors.

SYSTEMS OF BUYING MILK.

A few years ago by far the larger part of the milk handled by city dealers was bought from producers on the basis of the measure, that is, the can or the gallon. Dealers as well as producers have come to recognize the inaccuracy of this system and its unfairness, both to the buyers and to the farmers, so that in recent years the tendency has been to abandon it and adopt systems that are more nearly equitable and at the same time practicable.

The following bases are those in common use:

By the quart or gallon.

By the can, the size of the can varying from 8½ to 40 quarts or more.

By the can or the gallon, with a minimum standard for butterfat and a definite premium per gallon for each one-tenth per cent butterfat above standard.

A certain price per point butterfat per gallon.

Same as third way stated above, but with addition of a minimum standard for dairy farm score, and premium for extra points in this score.

By the can, the can of milk being required to come up to a standard weight.

By the gallon, the number of gallons being determined by dividing the weight by 8.6.

By weight, which is determined by the number of cans, each can being supposed to hold a certain quantity of milk by weight.

By weight, the milk being weighed at receiving station or at city plant. The milk is usually dumped into a tank for weighing. In some cases it is weighed in the cans and the weight of cans (tare) is deducted from the total weight of cans and milk.

On the weight basis, with a minimum standard for butterfat and a premium for extra points. Sometimes the butterfat standard is established and additions or deductions are made for each one-tenth per cent above or below it. In some cases the premium is paid only for milk of three-tenths per cent or more above the standard, while the deductions begin at one-tenth per cent below.

A certain price per 100 pounds as base price, the base price being fixed differently for each month in accordance with the average butterfat content of the milk in that month, as shown by the experience of previous years; and a variation in the price per 100 pounds of from 4 to 8 cents for every one-tenth per cent butterfat above or below the standard butterfat content for that month. If milk is below 2.8 per cent butterfat, only its butterfat is paid for. If any milk contains less than 8.5 per cent solids-not-fat, a suitable deduction is made. The price allowed per point butterfat is usually higher in winter than in summer.

Grading milk, and paying a price for Grade B per 100 pounds consisting of 3 to 4 cents per one-tenth per cent butterfat; for Grade A, an additional 5 cents per 100 pounds; and for Grade C, 5 cents less per 100 pounds. Grades to be determined on basis of (1) bacterial content, (2) sediment, (3) acidity, (4) flavor and odor, and (5) temperature on arrival in city.

So much per pound butterfat.

A certain price for a pound of butterfat and for 100 pounds of skimmed milk.

Same as above, except that the weight of the whole milk is considered instead of the skimmed milk.

So much per point (one-tenth per cent butterfat).

Milk should not be bought on a measured-gallon basis. Whether it is paid for by the gallon or by the pound it should be weighed at

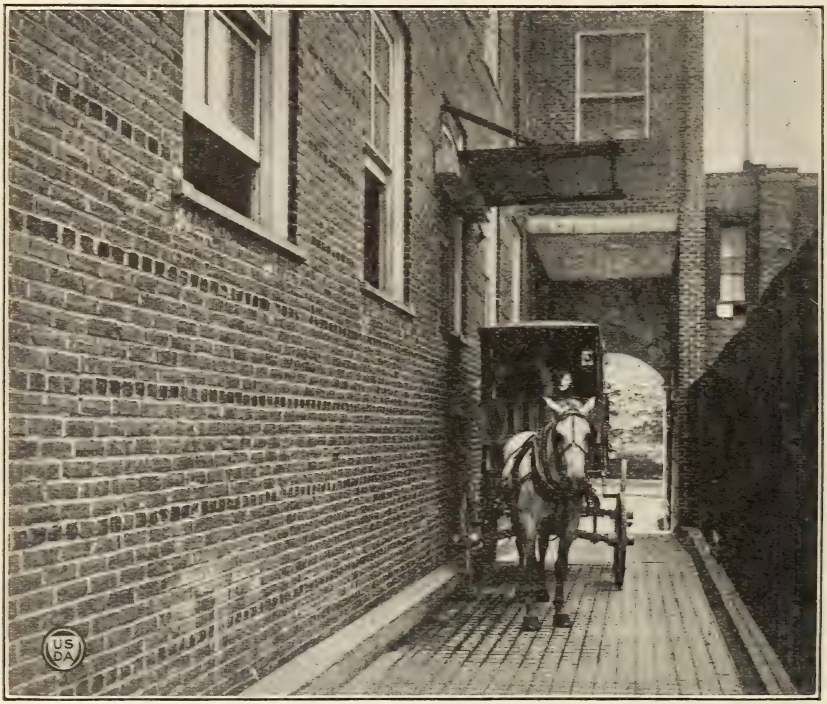

FIG. 25.—Unloading delivery wagon. The driver puts the cases of empty bottles through the small door to the conveyer. At eight plants using this system an average of 30 wagons was unloaded per hour.

the plant. If the milk is paid for by the gallon, the weight can readily be reduced to gallon measure.[8]

The butterfat is the most valuable constituent of milk and is being considered more and more as a basis in paying for the milk.

In 1914 a survey was made in four of the larger eastern cities and of the 87 plants visited 60 were making no attempt to weigh the milk. The proportion of dealers who are using the weight system is much larger now than at that time, yet a large number of dealers still use the can-measure system of determining the quantity of milk received from the producer.

The producer should receive full credit for all milk shipped, but the aim should be to use a system that is accurate and fair to both

[8] See U. S. Department of Agriculture Bulletin No. 890, "Milk-Plant Equipment."

parties. Naturally the dealer does not want to pay for more milk than he receives, and the farmer wants to receive payment for the full quantity of milk shipped.

In an investigation carried on in 1920 some interesting data were obtained which illustrated the inaccuracy of the method of determining the quantity of milk received at the plant by can measure alone. Observations were made on a total of 346 shipments of milk consisting of 1,102 cans. The cans of milk were examined on arrival at the plants before they were dumped into the weigh cans. The quantity of milk by measure in cans that were not full was estimated by means of measuring sticks, so that regardless of the quantity shipped by the producers and the amount lost before the milk reached the plants, an accurate check was made upon the fullness of the milk

FIG. 26.—Weighing milk. One man does nothing but record the weights. Note overhead-lever type of scales.

cans before they were emptied into the weigh cans. The table shows the difference between the quantity of milk dumped, as determined by can measure, and the actual quantity received, as shown by the scales.

Difference between can-measure and actual-weight receipts of market milk in 346 shipments.

Number of cans		1.102
Quantity received, by can measure	gallons	6.185
Quantity received, at 8.6 pounds to gallon	pounds	53.191
Quantity received by actual weight	do	52.191
Difference	do	1.000
Per cent of shortage		1.88

Thus the shortage in the total quantity of milk received was 1,000 pounds, or 1.88 per cent. The difference no doubt was due primarily

to the poor cans that were used. It can not be expected that dented and battered cans will hold the full amount. One shipment of 6 full cans supposed to hold 30 gallons held only 28½ gallons as shown by the weigh can. These cans were old and were badly dented and battered.

In justice to the producer at plants where milk is weighed, the scales used should be tested from time to time for accuracy, and the milk should be well drained from the cans into the weigh can.

DISPOSAL OF SURPLUS MILK.

Although in many cities systems of paying for milk have been worked out whereby the prices paid have a tendency to induce farmers to adjust their production more nearly to the city demands for market milk and reduce the surplus received, the surplus problem is neverthless an important one for the milk-plant manager.

The greatest amount of surplus milk is received in most cities in the spring and early summer months. As illustrated in Table 14, unusually large quantities of milk were received in Boston, Philadelphia, and Pittsburgh from May to September, and the greatest surplus occurred in the months of May, June, and July; while in the case of Detroit, where there is a considerable demand for milk in the summer, the greatest surplus occurred during February, March, and April.

TABLE 14.—*Monthly receipts and sales of market milk at cities named, during 1918, expressed as percentages of average receipts and sales.*

(Tabulation of figures received from some of the largest dealers in each city.)

Month.	Boston.			Philadelphia.			Pittsburgh.			Detroit.		
	Receipts (in per cent of average monthly receipts).	Sales.		Receipts (in per cent of average monthly receipts).	Sales.		Receipts (in per cent of average monthly receipts).	Sales.		Receipts (in per cent of average monthly receipts).	Sales.	
		In per cent of receipts.[1]	In per cent of average monthly sales.		In per cent of receipts.[1]	In per cent of average monthly sales.		In per cent of receipts.[1]	In per cent of average monthly sales.		In per cent of receipts.[1]	In per cent of average monthly sales.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
January	77.1	76.8	92.5	79.1	85.2	81.3	38.7	81.9	72.5	97.7	92.8	77.2
February	73.6	76.5	87.9	78.6	87.4	83.0	39.5	72.8	65.7	95.7	63.6	74.3
March	89.8	71.3	100.0	88.7	79.7	85.3	51.3	64.7	75.9	106.9	66.2	86.5
April	98.2	62.0	95.0	90.6	80.7	88.3	107.0	43.7	107.0	105.1	68.6	88.3
May	128.2	51.5	103.2	118.1	70.1	99.8	160.6	28.3	103.9	104.3	82.8	102.9
June	148.6	39.0	90.6	126.7	66.2	100.7	158.0	26.7	96.6	102.3	87.1	108.7
July	128.7	51.9	104.4	112.8	82.3	112.0	141.7	32.8	106.6	96.8	95.1	112.5
August	108.5	71.0	120.3	109.8	87.0	115.2	121.8	41.5	115.7	99.8	95.3	116.1
September	96.4	71.9	108.3	102.7	83.9	104.0	107.7	41.5	102.2	91.4	94.1	105.3
October	90.5	79.5	112.5	102.6	96.1	119.0	97.6	54.9	122.6	101.7	89.8	111.6
November	76.3	75.8	90.4	94.6	93.0	106.1	81.9	63.2	118.5	93.7	93.3	107.0
December	84.1	72.3	94.9	95.7	91.2	105.3	94.2	52.4	112.8	104.6	85.9	109.6
Average	.....	64.0	.....	.....	82.9	.....	.....	[2] 43.7	.....	.....	81.8	.....

[1] The per cent of surplus can be determined by subtracting from 100.
[2] A large quantity of milk was condensed here.

Each milk-plant operator must determine for himself how to dispose of a surplus to best advantage in his particular locality. Market demands and prices are of course the important factors in determining

what products can be manufactured most advantageously from the milk that can not be disposed of at market milk prices.

The following calculations illustrate how the returns may be figured on various products that can be made from surplus milk. The values here attached to the various products are arbitrary, and the actual prices will depend, of course, to a great extent on the particular locality. The following arbitrary values are used:

Butter	per pound	$0.50
Buttermilk	per gallon	.20
Cottage cheese	per pound	.05
Sweet cream	per gallon	1.50

Value of by-products from 100 pounds of surplus milk, at assumed prices.

Butter, cottage cheese, and buttermilk:	
The cream from 100 pounds of 4 per cent milk will make approximately 4.75 pounds of butter, at 50 cents	$2.38
And 1 gallon of buttermilk, at 20 cents	.20
The skim milk will produce approximately 9 pounds of cottage cheese, at 5 cents	.45
	3.03
Sweet cream and cottage cheese:	
100 pounds of 4 per cent milk will make approximately 2.5 gallons of 20 per cent cream at $1.50	3.75
And approximately 8.75 pounds of cottage cheese, at 5 cents	.44
	4.19
Butter and buttermilk:	
100 pounds of 4 per cent milk will make approximately 4.75 pounds of butter, at 50 cents	2.38
And approximately 10 gallons of buttermilk, at 20 cents	2.00
	4.38
Sweet cream and artificial buttermilk:	
100 pounds of 4 per cent milk will make approximately 2.5 gallons of 20 per cent cream, at $1.50	3.75
And approximately 9 gallons of artificial buttermilk, at 20 cents	1.80
	5.55

Thus with the prices given it would be more profitable for the dealer to separate the surplus and sell the sweet cream and make buttermilk from the skim milk. As stated, however, these figures are given merely for illustration; the cost of manufacture, market demand, and the prices that can be procured for the products must be considered in each case. Such illustrations will assist a dealer in determining what prices he can afford to charge for certain products as compared with prices of other products, as well as in determining what products can be made most advantageously from his surplus milk.

The market for cottage cheese is limited and irregular. Usually there is a good demand for good butter, and many plants are able to make a considerable number of cash sales of butter and buttermilk at the plant. Whether sweet cream can be disposed of readily depends on the locality. Some dealers who have a large surplus manufacture it into less perishable products, such as condensed and powdered milk, casein, etc., but, of course, this practice would not be practicable for a small plant. In the case of all products the relative cost of manufacture and marketing should be considered.

MANUFACTURE OF BY-PRODUCTS.

A milk-plant operator should be familiar with the manufacture of the ordinary by-products.

COTTAGE CHEESE.

For directions on the manufacture of cottage cheese, reference is made to United States Department of Agriculture Bulletin No. 576, "The Manufacture of Cottage Cheese in Creameries and Milk Plants."

BUTTERMILK AND ARTIFICIAL BUTTERMILK.

One of the most economical ways of disposing of surplus milk is by the sale of buttermilk or of artificial buttermilk. Skim milk or sour milk can be utilized profitably in this way. It takes practice and experience to be able to obtain a uniformly good product, but the following notes may be of assistance to those not familiar with the process:

Clean, sweet skim milk or whole milk should be used, and pasteurization is preferable, as it insures a better product from both a commercial and a sanitary standpoint. If skim milk is used better results are obtained if some whole milk is mixed with it, as 1 part whole milk to 3 parts skim milk. Run the milk after pasteurizing into a water-jacketed vat, and add good, clean starter enough to ripen the milk by the time wanted for churning. From 5 to 10 gallons of starter for each 100 gallons of milk should be sufficient. Take particular care to keep a good starter on hand, renewing it as often as necessary. Cover the vat to keep out flies and dirt, and ripen the milk at a temperature of from 60° to 70° F. The ripening temperature depends upon the amount of starter added and the length of time which the milk has to stand. Ripen the milk until it is coagulated into a rather soft curd. If the milk ripens too rapidly, run cold water around the vat to check the process. When the milk is ready, strain it into the churn, and churn for about 20 minutes, or until the butter has gathered in small granules. The milk should be churned at between 55° and 65° F. When butter comes, strain the buttermilk and cool it *at once*, using a cooler if possible. If no cooler is available, put the cans immediately into a tank of ice water or a refrigerator. If possible, bottle the retail buttermilk at once. Whenever possible, use a separate bottler for buttermilk. If not possible, particular care should be taken in washing and sterilizing the machine after buttermilk has been handled.

Further information on this subject is given in United States Department of Agriculture Bulletin No. 319, "Fermented Milks," which may be obtained from the Superintendent of Documents, Government Printing Office, for 5 cents; stamps not accepted.

WEIGHTS OF MILK AND CREAM.

In general the specific gravity of milk and cream depends on the percentage and relation of the solids, the temperature at which the determinations are made, and the age of the milk. The weight of 1 gallon of water at 68° F. (20° C.) according to the Bureau of Standards is 8.32162 pounds. Using this figure as the weight of

water and using the specific gravities of milk and cream of various percentages as given in United States Department of Agriculture Bulletin No. 98, the following table has been worked out as to the weights per gallon, at a temperature of 68° F.

TABLE 15.—*Weight per gallon and specific gravity of milk and cream having various fat contents.*

Commodity.	Fat content.	Specific gravity.	Weight per gallon.	Commodity.	Fat content.	Specific gravity.	Weight per gallon.
	Per cent.		*Pounds.*		*Per cent.*		*Pounds.*
Water		1.000	8.32162	Cream	20	1.013	8.4298
Skim milk	0.025	1.037	8.6295	do	22	1.011	8.4132
Milk	3	1.034	8.6045	do	25	1.008	8.3882
Do	3.5	1.033	8.5962	do	28	1.006	8.3715
Do	4	1.032	8.5879	do	30	1.004	8.3549
Do	5	1.031	8.5796	do	32	1.002	8.3383
Do	6	1.030	8.5713	do	35	.999	8.3133
Mixed milk and cream	10	1.025	8.5297	do	38	.997	8.2967
Do	15	1.018	8.4714	do	40	.995	8.2800
Cream	18	1.015	8.4464				

Weights are given at 68° F. because that is the temperature used in determining the specific gravities, being equivalent to 20° C., the temperature generally used for such work. There would be a slight difference for milk at 50° to 60° F., the temperature at which milk is usually received at the plant.

The determinations above were made on standardized milk and cream, that is, mixtures of skim milk and cream of various percentages of butterfat. Figures for normal milk containing from 3 to 6 per cent butterfat would vary slightly from those given. For all practical purposes the weight of whole milk may be figured at 8.6 pounds a gallon.

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